SUBTERRANEAN APHIDS OF OHIO

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SUBTERRANEAN APHIDS OF OHIO

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INTRODUCTION

The many unsolved problems dealing with subterranean insects testify to the difficulty of biologic and economic work of this nature. Among these, none are more perplexing than the one concerned with the various species of underground aphids. If we consult the literature dealing with species such as the corn root louse, *Anuraphis maidi-radicis* (Forbes); the grape vine phylloxera, *Phylloxera vitifoliae* Fitch; the woolly apple aphis, *Eriosoma lanigerum* (Haus); and the strawberry root louse, *Aphis forbesii* Weed, we can easily see that many entomological workers have devoted much time and energy to this problem. Life histories have been studied in detail and there are few remedies or control practices, known in the economic field, that have not been tried against them. In some cases this work has been successful. Resistant stocks have almost solved the problem of the grape vine Phylloxera; rotation has robbed the corn root louse of its most destructive powers.

The above are economic species of the first order and it is easily understood why they should have received so much attention. However, there are many other subterranean species that are of interest from both an economic and a biologic standpoint. The black peach aphis, *Anuraphis persicae-niger* Smith, at certain places, is a limiting factor in the starting of young trees and in the growing of seedling peaches for budding stock; *Geoica squamosae* Hart and allied species at times cause considerable damage to wheat and to grasses; and the aster root louse, *Prociphilus erigeronensis* (Thomas), frequently kills out entire plantings of cultivated asters.

Biologically, the different species offer a remarkable study of independent evolution toward a common end—namely, the underground habitat. There is no group of insects that possesses interrelationships with other groups of a more complex or remarkable character than the interrelationship of these subterranean aphids with ants. The underground species *Anoecia querci* (Fitch) was used by Osborn to establish the fact of seasonal migration from one host to another belonging to a non-related genus. This fact opened up a new field in aphid work. With this as a basis, Gillette, Patch, Baker, and others have made notable additions to our knowledge of many economic species.

Despite the large amount of work that has been done with certain underground species, there are many that have been almost totally neglected. The data concerning them have usually been taken while work on some major project was under way. As they were incident to more important work, they are fragmentary and of a very disconnected nature. At times the damage done by some of these obscure species has been severe, and it was thought worth while to make a somewhat extended study of this little known group.

The difficulty of work with underground aphids cannot be appreciated by one who has not tried experimenting with them. Their normal habitat requires that they be out of sight, on roots, in the soil; a condition that precludes detailed observation. Most species are strongly gregarious and refuse to lead a normal existence when alone. They are especially sensitive to light, to disturbance, and to changes of humidity in the soil. In addition, most species are so dependent on ants that they cannot be successfully handled away from them. Colonies of ants must, therefore, be established about the roots on which one wishes the aphids to live. This in itself is no easy task; but, when we add to it the care necessary to obtain exact data without exposing the ants to the disturbing influences of changes in light, moisture, etc., we find that it is almost an impossibility. The facts stated in this paper were obtained largely by continuous observation in the field. This was supplemented by laboratory and controlled studies in the open. Due to the nature of the problem, a great mass of detailed observations, such as usually accompanies aphid studies, was not secured. More attention was given to habits, interrelationships, migration, host plants, habitats, reactions, and economic considerations.

The writer is deeply indebted to Prof. H. A. Gossard, of the Ohio Agricultural Experiment Station, for many helpful suggestions and on whose staff he has served as assistant entomologist while pursuing this investigation. I am likewise indebted to Prof. Herbert Osborn, of Ohio State University, who had general direction of this work for the University and whose interest and suggestions were a source of constant encouragement. Several other entomologists contributed notes, gave suggestions, and made identifications that were of great assistance. These were Mr. J. S. Houser, Dr. A. C. Baker, Dr. E. M. Patch, Mr. P. W. Mason, Dr. T. L. Guyton, Dr. J. W. Bulger, Mr. M. R. Smith, Dr. L. L. Huber, and Mr. A. E. Miller. To all of these I express my appreciation of their aid. I have been indirectly assisted by two others: by my wife, Dr. Eva Goddin Cutright, whose interest in this problem has been a great pleasure to me, and by my uncle, Mr. F. E. Brooks, to whose early encouragement my entomological endeavors are due.

LIST OF OHIO SPECIES OF UNDERGROUND APHIDS

The following underground species have been collected in Ohio: *Anoecia corni* (Linn.), *Anoecia querci* (Fitch), *Anuraphis bakeri* (Cowen), *Anuraphis crataegifolii* (Fitch), *Anuraphis maidi-radicis* (Forbes), *Anuraphis persicae-niger* (Smith), *Anuraphis middletoni* (Thomas), *Anuraphis viburnicola* (Gill.), *Aphis forbesii* Weed, *Hysteroneura setariae* (Thomas), *Rhopalosiphum prunifolium* (Fitch), *Colopha ulmicola* (Fitch), *Eriosoma lanigerum* (Hausmann), *Tetraneura graminis* Monell, *Pemphigus lactucae* (Fitch), *Pemphigus populi-transversus* Riley, *Prociphilus tessellata* (Fitch), *Prociphilus erigeronensis* (Thomas), *Forda olivacea* Rohwer, *Geoica squamosae* Hart, and *Geoica radicicola* (Essig). *Forda formicaria* Kalt. may be expected in Ohio.

KEY TO SUBTERRANEAN GENERA (alates)

1.	With cornicles	2
	—Without cornicles	10
2.	Cornicles as elevated rings on broad flat cones or mere rings on shallow cones	3
	—Cornicles elongate, definite	7
3.	Cornicles and antennae hairy, no wax glands	**Anoecia**
	—Wax glands or plates, annular or elongated oval sensoria, reduced wing venation	4
4.	Annular sensoria almost encircling the segment	5
	—Narrow transverse sensoria, antennae fairly short and thick	**Pemphigus**
5.	Media of fore wing simple, only media present in hind wing	**Tetraneura**
	—Media of fore wing once branched	6
6	Hind wing with both media and cubitas present	**Eriosoma**
	—Hind wing with media only, antennae rather short and thick	**Colopha**

7. Cornicles swollen near distal end but with a constriction just before a flaring opening	**Rhopalosiphum**
—Cornicles straight or slightly tapering	8
8. Cauda short, stout, and abruptly conical	**Anuraphis**
Cauda slender, slightly constricted near base	9
9. Hind wing with one oblique vein (media) present	**Hysteroneura**
—Hind wing with two oblique veins	**Aphis**
10. Antennae fairly elongate and slender, strong thoracic wax plates	**Prociphilus**
—Antennae short and stout	11
11. Annular sensoria, almost encircling the segment	12
—Oval or narrow transverse sensoria	13
12. Media of fore wings once branched	**Colopha**
—Media simple	**Tetraneura**
13. Weak thoracic wax plates, narrow transverse sensoria..	**Pemphigus**
—Stout antennae with oval sensoria	14
14. Antennae of five segments	**Forda**
—Antennae of six segments, no central thoracic wax plate	**Geoica**

KEY TO SUBTERRANEAN GENERA (apterae)

1. With cornicles	2
—Without cornicles	6
2. Cornicles as elevated rings on broad flat cones or as mere rings on shallow cones	3
—Cornicles elongate definite	4
3. Antennae and cornicles hairy, no wax glands	**Anoecia**
—Antennae not hairy, sensoria annular, many wax glands	**Eriosoma**
4. Cornicles slightly swollen near distal end but with a constriction just before a flaring opening	**Rhopalosiphum**
—Cornicles straight or slightly tapering	5
5. Cauda short, stout, and abruptly conical	**Anuraphis**
—Cauda slender, slightly constricted near base	**Aphis** or **Hysteroneura**
6. Wax glands poorly developed, no wax tufts, may be covered with a whitish powder	7
—Wax glands present, and evident in living forms	8
7. Third antennal joint three to four times longer than others	**Forda**
—Third antennal joint subequal, body usually with spines or squamae	**Geoica**
8. Body with wax glands grouped definitely about tip of abdomen	**Pemphigus**
—Body with wax glands evenly distributed in rows over the surface	9
9. Antennae extremely short, segments broad as long.....	**Colopha** or **Tetraneura**
—Antennae of fair size, segments much longer than broad	**Prociphilus**

SUBTERRANEAN APHIDS IN GENERAL

Different species of subterranean aphids are scattered widely thruout the family Aphidae. Baker lists nineteen genera which contain underground species, wholly or in part. Of these, eight belong to the subfamily Aphidinae and eleven to the Eriosomatinae. The subfamilies Minderinae and Hormaphidinae are not represented among the underground species. According to our present knowledge, genera such as *Trama, Neotrama, Protrama, Forda, Geoica,* and *Paracletus* may be considered as truly subterranean in that individuals appear above ground only for migration to new hosts where they at once seek the roots.

In other genera conditions are somewhat different. Species from the genus *Anoecia* are able to live year after year below the surface, tho a few individuals will pass a portion of each year above ground. The same may be said of species from the genus *Prociphilus,* tho one form at least is able to spend years below ground without any indication of leaving this habitat. In the genus *Anuraphis* we find several species that are quite similar to the above, tho they all vary in many details. It is probable that the woolly apple aphis, *Eriosoma lanigerum* Haus., can live almost indefinitely on the roots of apple, but it can maintain itself for only a portion of the year on its alternate host, the elm. In certain countries of the world where *E. lanigerum* has been introduced on the roots of apple, elms are not present. In spite of this fact this aphis has been present for many years and is frequently a severe pest. In some parts of Canada and in northeastern United States, the migration to and from the elm is very heavy and it is possible that the elms may here be a necessary factor in the life cycle. The cockscomb gall aphid of the elm, *Colopha ulmicola* (Fitch), spends several months of the year on this host, then goes to grass roots. It is, then, entirely possible that individuals of the species may stay several years underground before conditions arise that bring about a return migration. Examples from other genera could be given but the above illustrations show the general condition.

The idea of complete and enforced spring and autumn migration is applicable to some aerial forms but has yet to be proved for any subterranean species. When we consider the aphids that spend all or some portion of their life cycle underground we are forced to conclude that migration was the rule at some time or other in their past history. In those subterranean species where we are unable to establish the fact of migration to an alternate host, we naturally inquire as to the reasons for its non-existence. Several theories may be offered in explanation.

First. The migration may still occur, but to such a small degree that the very few migrants that reach the alternate host have never been found. In several species winged forms appear in the autumn in small numbers. These may find their way to an alternate host where the sexual part of the cycle is completed. In favor of this theory we can point out species such as *Eriosoma lanigerum* (Haus.), *Anuraphis roseus* Baker, and *Macrosiphum solanifolii* (Ash.), whose true host relationships were discovered only after years of research. In the underground species, migrants appear in far smaller numbers. The difficulty of finding an alternate host under such conditions can be appreciated only by one who has done work along such lines. *Prociphilus erigeronensis* (Thos.) is an example of the above possibility.

Second. In the evolution of an underground species, individuals have developed that can live thru the winter in the soil. This method of life has been more favorable for the species and consequently the migratory habit is slowly dying out. *Anoecia querci* (Fitch) still migrates in limited numbers to Cornus but most of the individuals remain thruout the year in the soil. It seems possible that such a condition could have been carried further in other species so that migration may have ceased altogether. The few winged individuals that appear each autumn are no longer an integral part of the life cycle but are simply reversions to a past condition.

Third. The alternate host plant may have disappeared. Mordwilko points out several species falling in the scope of this theory. In Europe and the United States several species of *Forda* exist on grass roots with no alternate host. In Asia Minor they migrate to *Pistacia,* which serves as the primary host, where the sexual part of the cycle takes place. Geological evidence shows that at one time *Pistacia* was native to Europe and the United States but that it was probably killed out during the Glacial Period. Likewise in Siberia, a *Tetraneura* lives on grass roots. Elms, which are the alternate host for the genus, are absent but fossil remains show that they were present at one time. In Transbaikalia a species of *Prociphilus* lives continually on *Alnus.* The maples which are the usual primary host have disappeared. The case of the woolly apple aphis, *Eriosoma lanigerum* (Haus.), has already been mentioned. Several other species can be cited in this connection. Mordwilko and Mason believe that the killing off of alternate hosts during the Glacial Period is the reason for the absence of migration in certain species. Mordwilko says of some forms that they "multiply exclusively parthogenetically" and that "*Forda trivialis* has entirely lost its sexuparae form". In those species where sexuparae occur they are called a "biological remnant".

Where migration has been proved or is likely to occur, more definite statements can be made. The underground forms infesting perennials would seem to have a better chance of escaping the perils of a migration than those feeding on the roots of annuals. This is largely true but there are exceptions; for instance, the corn root louse, *Anuraphis maidi-radicis* (Forbes), feeds usually on the roots of annuals but passes the winter in the egg stage in the soil. *Geoica squamosae* Hart and *Anoecia querci* (Fitch) spend the summer on the roots of annual grasses but most of them are cared for during the winter in the nests of ants. *Prociphilus erigeronensis* (Thos.) is cared for during the winter by ants but usually feeds on the roots of perennials. Other species spend the winter only on the roots. *Pemphigus lactucae* is normally found on the roots of its hosts but is capable of passing the winter alone in the soil. It is possible that *Prociphilus erigeronensis* (Thos.) may also pass the winter in the same way. To summarize the question of migration, there are so many differences as it occurs in the various species that no general rule can be formulated. We believe this is due to specialization in each species and to the wide range of phylogenetic relationships existing among the subterranean aphids.

Living in an underground habitat has arisen, in most cases at least, after the genus became established—that is, each species has developed the habit independently. In some genera, however, new species have probably originated after the underground habitat was adopted. Species in *Forda* and *Geoica* may be cited as examples of this possibility. In any genus where all the species are subterranean, we may suspect that this has taken place. In genera where we find some species aerial and others subterranean in habitat, we may suspect the opposite, since the aerial habitat is the more primitive. Ants undoubtedly played a prominent part in adapting some species to underground life. The strawberry root louse, *Aphis forbesii* Weed, which is carried below each year by the ants, seems to be passing thru this period at present. The corn root louse, *Anuraphis maidi-radicis* (Forbes), is an example of a more advanced condition in which the entire life is spent underground in the care of ants.

Several degrees of specialization exist in regard to the sexual stages. *Anuraphis maidi-radicis* (Forbes) and *Aphis forbesii*

Weed still possess the normal sexual cycle in which the egg stage is the only known method of overwintering. This is the more primitive condition. A further advanced stage is found in the genus *Anoecia* where the sexual cycle is still present but where the species is also able to overwinter as living nymphs and adults. The sexual forms of *Anuraphis persicae-niger* (Smith) have not been reported but it is probable that they exist on an alternate host. In *Eriosoma, Tetraneura, Prociphilus,* and *Pemphigus,* we find that certain species can exist for years without a manifestation of the sexual cycle but that this phase of the life history at times reappears. This is a further advancement. The most highly specialized forms are those in which the egg stage has entirely disappeared. Such species are found in *Forda, Geoica,* and others. Attention has been called to this condition in the discussion of the theories of migration.

The presence of wings is a primitive character among aphids; therefore, we find them most frequently in subterranean species related to the *Aphidinae*. An exception to this statement may be made in regard to the subtribe *Tramina*. In the *Eriosomatinae* the absence of winged individuals is much more noticeable. The development of antennal characters, cornicles, and wax glands shows little variation from those of the closely related aerial forms. There are also degrees of specialization in their relationships with ants. Some species get along quite well without ants while others are absolutely dependent on them. These latter I consider as being highly specialized. One species, however, I believe has gone to the other extreme. This is *Pemphigus lactucae* which lives entirely without the aid of ants but in other respects is very highly specialized.

When we consider the underground species as a group, we find that there are few habits, specializations, or characters that they have in common. All have a common habitat and most have relationships of varying degrees with ants. In reproduction all are parthogenetic and viviparous; but some seem to have lost the sexual stages, while others, tho the sexual stages are present, are not dependent on them. In other species the sexes are still a vital part of the life cycle.

In their reactions we find many similarities and some differences. Apterous forms from a species of *Pemphigus* show a positive geotropism, while some from the genus *Anuraphis* show opposite tendencies. This reaction is influenced by temperature. *Pemphigus* (alates) will crawl up at high temperatures, and some individuals of the *Anuraphis persicae-niger* (Smith) will move down at low temperatures. Almost all species move away from light, *A. persicae-niger* being the least responsive to this stimulus. All species are gregarious and group themselves together whenever possible. This tendency is a specialization, as the primitive aphids were solitary. In the first-instar nymphs of *Pemphigus lactucae* the solitary instinct still persists but gregarious tendencies develop during the period of growth. Some species in the soil will find, and locate themselves on, the roots of their hosts. It is doubtful if this is a form of chemotropism. Rather, it appears to be a matter of chance in finding the food while wandering thru the soil. Other species in all stages are absolutely dependent on ants for the location of food. All species thrive with a high percent of moisture present. Temperature, within limits, influences the rate of reproduction and general activity much as in other *Aphidae.* In common with aerial plant lice, they are active and can reproduce at low temperatures. They will be killed by temperatures that do not injure most insects. Their reactions to thigmotropism are mostly positive. However, the early instars of *Pemphigus lactucae* show no response to this tropism but develop it as they grow older, and the adults of *Anuraphis persicae-niger* (Smith) are at no time influenced by this tropism.

All subterranean species are remarkably free from the attacks of parasites and predators. Thruout the course of these studies I paid particular attention to this point. I found but one individual, an apterous female of *Anuraphis maidi-radicis* (Forbes), that was parasitized. This parasite was bred out but unfortunately was destroyed before it was determined. In the many colonies that I examined I never found one that was being attacked by predators of any species. Also I noticed freedom from the attacks of fungi, which so frequently destroy large infestations of aerial aphids. The above facts we consider as advantages for the subterranean habitat. Other advantages of the subterranean habitat are that the insects are not exposed to birds, toads, and other enemies, nor are they subject to the extremes of temperature and humidity that prevail above ground. The latter was clearly shown by study of soil temperature and moisture carried on for two years.

The one great disadvantage of underground life is the difficulty of finding new and sufficient food. Colonies soon become crowded and will die out unless new food is located. Most species have overcome this by living with ants. Even in these cases the difficulty of finding food is the limiting factor in the life of the species.

BIOLOGY AND SYNONOMY OF SPECIES

Genus Anoecia Koch

1857 Koch, Die Pflanzenlause Aphiden, p. 275

This genus originally was considered as being related to the *Eriosomatinae,* largely because it was thought the sexual female produces only one egg. A special study of the genus by Baker has shown that its true position is among the more primitive Lachnini. It is placed here because of the structure of the cornicles and the fact that the sexes feed during most of their lifetime. Also cases are on record of females having laid more than one egg.

Two species of this genus are found in Ohio. They may be separated by the following key.

Antennae with ten to sixteen broad, transverse sensoria on III..........**corni**
Antennae with none to eight round to oval sensoria on III..............**querci**

Anoecia corni (Fab.)

Plates I, V

1775 *Aphis corni.* Fabricus, Syst. Ent., p. 736, (orig. desc.)
1843 *Schizoneura corni* (Fab.). Kaltenbach, Mon. der Fam. der Pflanzenlause, p. 168.
1860 *Schizoneura venusta.* Passerini, Gli Afidi, p. 38.
1881 *Schizoneura corni* (Fab.). Buckton, Mon. Brit. Aphids, p. 107, vol. III. pl. CX.
1885 *Anoecia corni* (Fab.) Lichenstein, Mon. des Aphidiens, pp. 67 and 87, (list).
1915 *Anoecia corni* (Fab.). Van Der Goot, Beitrage zur Kenntnis der Hollandlischen Blattlause, p. 507, (desc. and list).
1923 *Anoecia corni* (Fab.). Wilson, Hem. of Conn., p. 258, (desc. and list).

This aphis is most commonly found during the autumn months on the underside of the leaves of different species of dogwood, *Cornus.* It is a fairly large plant-louse, whose prevailing color is black. *Aphis cornifoliae* Fitch is also found on *Cornus* at the same season of the year. As the latter is a green aphid with clear wings there is little possibility of confusing the two. *Anoecia querci* Fitch is easily recognized by using the characters given in the above key.

Anoecia corni (Fab.) is a native of Europe and was introduced into this country probably about fifty years ago. It is doubtful if the date of introduction was earlier than 1875, since this species is not found in the collections of the entomologists of that period. In the collection of Fitch there is a slide of this species, but it was sent him by a European worker. The species was probably imported in the egg stage on the twigs of ornamental dogwoods. Distribution, at first limited to certain of the Atlantic coast states, has moved steadily westward. The species has been taken for several years in Ohio. The exact extent of its present range in America is unknown.

The species has been collected from the following hosts.

Aerial Hosts:
- *Cornus stolanifera* Mich., Red-osier dogwood
- *Cornus alba* Lam., Red-twig dogwood
- *Cornus sanguinea* L.
- *Cornus (paniculata) femina* Mill.

Subterranean Hosts:
- *Dactylis glomcrata*, Orchard grass
- *Agrostis alba* L., Redtop grass

Life history.—Among European authors we find that Lichtenstein was the first to state that this species migrates from *Cornus* to the roots of certain grasses. This was expressed more as an opinion than as a fact. Later other entomologists worked out the life cycle and Van der Goot makes a positive statement that such a migration does occur.

In American literature *Anoecia querci* (Fitch) has usually been referred to as *Anoecia corni* or *Schizoneura corni.* This was true till 1916 when Baker pointed out the differences between the two species. There is, therefore, little or no American literature dealing with *Anoecia corni.*

In the limited literature the impression is given that the spring and autumn migrations are "forced" and complete. That is, all individuals migrate at both seasons. If this were true, there would be only one method of overwintering for the species, this being in the egg stage on the twigs or branches of *Cornus.* This method is used by *A. corni,* but our observations have shown that it is not the only one. In fact its importance in the life cycle is doubtful. *Corni* also passes the winter in the soil, either on the roots of plants or in the nests of ants. Nymphs and adults are to be found during the winter in these positions. The abundance of fall migrants and sexual forms might lead one to believe that the winter egg plays an important part in the life economy of the species. The fact that so few eggs are laid offsets this observation. In the spring or early summer there are very few migrants returning to the grasses and it is impossible to think of these few as the mothers of the large number of apterous forms that are soon to be found on grass roots.

In April and May the ants place on the roots of orchard grass and redtop the individuals that have overwintered in their nests. A very few other individuals are already so located, having passed the winter in this position. Feeding and reproduction begin as soon as the temperature permits the resumption of normal metabolic processes. Reproduction occurs when the average temperature runs about 45 degrees F. for a few days. A widely fluctuating temperature prohibits reproduction, even tho the average be somewhat above 45 degrees.

The eggs hatch from the tenth of April on thru the first week in May, depending on the season. Stem mothers become mature and start reproduction in ten to sixteen days. Of their progeny a few may become winged but in most cases the alate forms do not appear till the third generation. Dates of the starting and completion of migration vary widely in different seasons. In 1923 winged individuals left the host plant May 3 to June 6. In 1924 no alates were seen till June 4, and the last were observed on *Cornus* on June 15. No *Anoecia* remain on *Cornus* during the summer.

The number of generations produced on the roots of grasses during the summer is not definitely known. The species does not reproduce as rapidly as the corn root louse, *Anuraphis maidi-radicis* Forbes—that is, it requires a longer period of time for each generation. Due to crowded colonies or other unfavorable conditions, winged forms may arise at any time during the summer. While we have never seen these forms leave the ground and fly to other plants, it is known that they do so. The apterous forms are frequently transferred by ants to new roots and there is a limited independent migration of nymphs and adults from old roots to new ones close by.

The relationship existing between the subterranean apterae and ants is very close. It is almost impossible to propagate the aphids on grass roots without a colony of ants at hand. The relation of ants to the overwintering aphids has been mentioned. There is no doubt that ants play a most important part in the life economy of the species.

The fall migration extends over a period of time several weeks longer than that of the spring migration. I took the newly arrived migrants of *A. corni* as early as September 3 and as late as November 18. They were taken at all times during this period of more than ten weeks. Within a few hours after the sexuparae settle on a leaf reproduction commences. One individual may give birth to both males and females. These develop in a week to ten days and copulation takes place usually before the females leave the leaf. Soon after this the females crawl to the branches where they spend many hours wandering up and down, each searching for a suitable place to deposit its single egg. From the small number of eggs to be found in late autumn it is evident that all females do not succeed in ovipositing. Dead females that seemed to have a shriveled egg still in their bodies were found.

Anoecia querci (Fitch)

Plate I

1859 *Eriosoma querci.* Fitch, Nox. and Ben. Insects of N. Y., Fifth Report, p. 804, (orig. desc.).
1862 *Eriosoma fungicola* and *E. cornicola.* Walsh, Proc. Ent. Soc. of Phil., vol. I, p. 304, (desc.).
1879 *Schizoneura panicola.* Thomas, Eight Ill. Report, p. 138, (desc.).
1887 *Schizoneura cornicola* (Walsh). Weed, Psyche, vol. V, p. 129, (desc.).
1889 *Schizoneura corni* (Fab.) Osborn, H., Insect Life, vol. II, p. 188, (bio.).
1890 *Schizoneura corni* (Fab.) Osborn, H., U. S. D. A., Div. of Ent. Bul. 22, pp. 32-41, (bio., syn., desc.).
1892 *Schizoneura panicola* Thos. Forbes, Eighteenth Ill. Report, pp. 75-82, (bio.).
1915 *Anoecia corni* (Fab.). Gillette and Bragg, Jr. Ec. Ent., vol. VIII, p. 100, (list).
1916 *Anoecia querci* (Fitch). Baker, A. C., Ent. News, vol. XXVII, pp. 359-363, (syn.).
1922 *Anoecia corni* (Fab.). Oestlund, Nineteenth Minn. Report, p. 146, (list).
1923 *Anoecia querci* (Fitch). Wilson, Hemiptera of Conn., p. 259, (desc.).

This aphid may be easily collected during the summer months from the roots of foxtail, *Setaria glauca* and *viridis,* and other wild grasses. In early spring and late autumn it may also be found on the roots of certain wild asters and goldenrods. In general the species resembles *A. corni,* tho it is smaller and there is less black on the abdomen and wings. *A. corni* and *A. querci* can be definitely identified only by the use of the characters given in the key. In order to use these, specimens must be examined under microscope.

The species was first described by Fitch (1859) from specimens taken on oak in Illinois. His description is lacking in detail and as the host is unusual, it escaped the attention of other American entomologists. Only an examination of the type slide leaves no doubt that it is the same species that was later described by Walsh as *E. fungicola* and *E. cornicola,* and by Thomas as *S. panicola.* Osborn, after his extensive work with this species, decided that it was the European *A. corni.* This was because none of the earlier entomologists mention the antennal sensoria which are the distinguishing characters. In U. S. Dept. of Agr. Bul. No. 22, Osborn says, "The most distinctive character of *A. corni* is perhaps the hairy antennae and the six or seven circular sensoria on the underside of the third antennal joint". This determines the species at once as *A. querci* rather than *A. corni,* in which the sensoria are transverse and from eleven to sixteen in number. Also in the collections of Osborn and Sirrine, I was unable to find any *A. corni.* The only *Anoecia* present was *A. querci.* In 1916 Baker obtained Fitch's Types and was thus able to give a complete synonomy.

The species has been collected from the following hosts.

Aerial Hosts:
- *Cornus florida* L., Flowering dogwood (rare)
- *Cornus stolonifera* Michx., Red-osier dogwood
- *Cornus amomum* Mill.
- *Cornus paniculata* L'Her.
- *Cornus sanguinea* L.
- *Quercus* sp.
- *Diospyros virginiana* L., Common persimmon

Subterranean Hosts:
- *Digitaria sanguinalis* (L.) Scop., Crab grass
- *Setaria glauca* L., Foxtail
- *Setaria viridis* L., Foxtail
- *Panicum capillare* L., Old-witch grass
- *Panicum virgatum* L., Switch grass
- *Aster ericoides* L., Wild aster
- *Aster novae-angeliae* L., The New England aster
- *Solidago graminifolia* (L.) Salisb., Fragrant golden-rod
- *Polygonum erectum* L.
- *Polygonum hydropiper* L., Smartweed
- *Poa pratensis* L., Blue grass
- *Andropogon scoparius* Michx.
- *Zea mays* L., Corn
- *Sorghum halepense* L., Sorghum
- *Muhlenbergia mexicana* (L.)
- *Phleum pratense* L., Timothy

The list of food plants indicates that there are many others as yet unknown.

This species overwinters in two ways—first, in the egg stage on the twigs of *Cornus,* and possibly other woody plants; second, as apterous forms in the soil, usually in ants' nests. More than nine-tenths of the individuals on roots at the end of the growing season do not migrate but remain in the soil. A large number of these are cared for by ants and part of them live thru the winter. Those that are left on the roots or alone in the soil usually die. I failed to find the species on roots during the winter and also was unable to overwinter them in vials filled with earth, either in the soil or in cold storage. However, I found them in ants' nests in December and on roots in April. Here they were always cared for by ants. Forbes gives a record of this species being taken in an ant nest in a log April 5, and in the burrows of ants in late November. He also states that it is common on the roots of timothy, bluegrass, and native grasses when the sod is being broken up in the spring. Osborn and Baker have taken oviparous females from roots in the soil and it is possible that some eggs may be overwintered by ants much as in the case of the corn root louse.

The apterous forms that overwinter are placed on roots by ants, usually in April. This is from a month to six weeks before the first return migration from *Cornus* begins. Each aphid colony is attended proportionately by many more ants than will be present later in the season. I found the species first on the rootstalks of perennials such as *Solidago graminifolia* and *Aster ericoides,* and later, on grass roots.

Winter eggs on *Cornus* are few and hard to find. That they do occur is proved by the presence of stem mothers and their offspring during May and early June. These are most frequently located on the cluster of flower buds. Spring migrants arise usually in the third generation and migration coincides with that of *Anoecia corni.* The number of migrants returning to grass roots is so small that it can have little or no significance in the life of the species.

Reproduction on the roots is not as rapid as in the case of the corn root louse, since it usually takes two to three days more for each individual to complete its growth. It is rapid enough, however, to soon cause crowding in the limited space occupied by the colony. This explains why pupae are at times found on the roots before the migration from *Cornus* has started and how winged forms may be present as early as June 5. Alates may be found on roots during June, July, and August. These aid in the distribution of the species by flying to new host plants where they are usually taken to the roots by ants. A small proportion may succeed in reaching the roots unaided.

I took fall migrants from *Cornus* as early as September 22 and conditions showed that they had been present for three or four days. They were collected as late as October 30. *A. querci* constituted only a very small percent of the *Anoecia* present on *Cornus* during this period. The migration was also shorter than that of *A. corni.* Both of the above conditions varied according to the season. After November 1 the only *A. querci* that I was able to find were those either on the roots of perennial grasses or weeds or in the nests of ants.

The main points of interest are:

First, *A. corni* was taken only on the roots of orchard grass and redtop. *A. querci* was never taken on these two hosts.

Second, both species migrated, but the migration of *A. corni* was much more pronounced.

Third, both species were largely dependent on ants for their well-being, in summer as well as in winter. *A. querci* seemed to be more dependent on them than *A. corni*.

Genus **Anuraphis** Del Guercio

1907 Del Guercio, Redia, vol. 4, p. 190

This genus was separated from *Aphis* because of the caudal characters. In *Aphis* the cauda is slender and slightly constricted near the base while in *Anuraphis* it is "short, broad, and abruptly conical." There are a number of "borderline" species with intermediate characters, which may be placed arbitrarily in either genus. Most species in the genus are aerial; but some, such as the corn root louse, *Anuraphis maidi-radicis* (Forbes), are entirely subterranean. The other species considered here spend at least a portion of their life cycle underground.

Key to Ohio species (alates)

(Adapted from an unpublished key by Baker)

1. Cornicles with transverse rows of minute chitinized points	2
—Cornicles without these points but smooth or imbricated	4
2. Hind tibia with numerous sensoria on distal half, (spring migrant)	**Viburnicola**
—Hind tibia without such sensoria	3
3. Beak not extending beyond hind coxae	**Bakeri**
—Beak extending beyond hind coxae	**Crataegifoliae**
4. Sensoria on segment III of antennae in even row and sensoria on IV	**maidi-radicis or middletonii**
—Sensoria on segment III, scattered and numerous	**persicae-niger**

Anuraphis bakeri (Cowen). The clover aphis

Plate I

1895 *Aphis bakeri* Cowen and *Aphis cephalicola* Cowen, Gillette and Baker, C. F., Hemip. of Col., Agr. Exp. Sta. Bul. 31, p. 118 (orig. desc.).

1908 *Aphis bakeri* Cowen, Gillette and Taylor, Col. Agr. Exp. Sta. Bul. 133, p. 28, pl. 3. (bio., desc., and syn.).

1908 *Aphis bakeri* Cowen, Gillette, Jr. Ec. Ent., vol. 1, p. 264, pl. 9. (bio. & desc.).
1908 *Aphis bakeri* Cowen, Davis, Ann. Ent. Soc. Amer., vol. 1, p. 259, pl. 23. (bio. and desc.).
1909 *Aphsi bakeri* Cowen, Webster, R. L., Jr. Ec. Ent., vol. 2, p. 211. (damage.).
1915 *Aphis bakeri* Cowen, Patch, Jr. Agr. Res., vol. 3, p. 431. (bio. and desc.).
1918 *Aphis bakeri* Cowen, Gillette and Bragg, Jr. Ec. Ent., vol. 11, p. 333. (key).
1920 *Anuraphis bakeri* (Cowen), Quaintance and Baker, Farmers' Bul. 1128, p. 12. (bio.).
1923 *Anuraphis bakeri* (Cowen), Smith, R. H., Agr. Exp. Sta., Univ. of Idaho, Res. Bul. 3, (complete account).

As yet this species has not proved to be of economic importance in Ohio. It spends the winter in the egg stage on apple, crab apple, quince, plum, sweet cherry, and hawthorne. In summer the aphids migrate to different species of clover. In Ohio red clover, *Trifolium pratense,* seems to be the favorite host. It usually occurs on the leaves or blossoms but at times about the crown and on roots near the surface of the soil. In some western states this aphid is a limiting factor in the production of clover seed.

Anuraphis crataegifoliae (Fitch). The thorn leaf aphis

Plate I

1851 *Aphis crataegifoliae,* Fitch, Homop. of N. Y., p. 66, (orig. desc.).
1901 *Aphis brevis* Sanderson, Twelfth Del. Report, p. 157, (desc.).
1904 *Aphis crataegifoliae* Fitch, Sanborn, Kan. Univ. Sc. Bul. no. 3, p. 53, (desc.).
1910 *Aphis crataegifoliae* Fitch, Davidson, Jr. Ec. Ent., vol. 3, p. 377, (list).
1915 *Aphis brevis* Sanderson, Patch, Jr. Agr. Res., Vol. 3, pp. 431-433 (bio. and desc.).
1918 *Aphis crataegifoliae* Fitch, Gillette and Bragg, Jr. Ec. Ent., vol. 11, p. 333, (key).
1919 *Aphis crataegifolii* Fitch, Swain, Aphididae of Cal., p. 100 (list).
1919 *Anuraphis crataegifoliae* (Fitch), Baker, Proc. Bio. Soc. Wash., vol. 23, p. 185, (syn.).
1920 *Anuraphis crataegifoliae* (Fitch), Quaintance and Baker, Farmers' Bul. 1128, p. 14 (bio.).
1923 *Anuraphis crataegifoliae* (Fitch), Patch, Hemip. of Conn., p. 298, (list).
1923 *Anuraphis crataegifoliae* (Fitch), Guyton, Ohio Aphididae, p. 13 (list).

This aphid is frequently taken on the leaves of Hawthorne, *Crataegus,* and allied species. In the summer it migrates to clovers and peas where it is at times found about the base or on the roots of the plants. It possesses little economic importance, tho at times it may attack the leaves of quince.

Anuraphis maidi-radicis (Forbes). The corn root louse

Plate II

1891 *Aphis maidi-radicis*, Forbes, Seventeenth Ill. Report, p. 64, (orig., desc.).
1892 *Aphis maidi-radicis*, Forbes, Eighteenth Ill. Report, pp. 50-75, (complete account).
1908 *Aphis maidi-radicis*, Forbes, Ill. Bul. 130, (control).
1909 *Aphis maidi-radicis*, Forbes, Twenty-fifth Ill. Report.
1909 *Aphis maidi-radicis*, Forbes, Davis, U. S. D. A., Bur. Ent., Tech. Ser. 12, Part 9.
1910 *Aphis maidi-radicis*, Forbes, Vickery, U. S. D. A., Bur. Ent., Bul. 85, Part 6, (complete account).
1915 *Aphis maidi-radicis*, Forbes, Forbes, Twenty-eighth Ill. Report, pp. 1-58, (control).
1917 *Aphis maidi-radicis*, Forbes, Davis, Farmers' Bul. 891, (bio. and control).
1923 *Aphis maidi-radicis*, Forbes, Patch, Hemip. of Conn., p. 294 (list).
1923 *Anuraphis maidi-radicis* (Forbes), Guyton, Ohio Aphidae, p. 13 (list).

Thruout the central states there is probably no aphid pest of greater importance than the corn root louse. Many acres of corn are destroyed or have the yield greatly reduced each year because of it. In Ohio it is only occasionally a severe pest. This is due to the general practice of crop rotation, which is the best known method of control. This insect spends its entire life cycle on the roots of plants and in the soil, constantly attended by ants. Even the eggs of the aphids are carefully tended over winter. This aphid is not discussed in detail because of the many excellent publications dealing with it.

Anuraphis middletonii (Thos.)

1879 *Aphis middletonii* Thomas, Eighth Ill. Report, p. 99, (orig. desc.).
1910 *Aphis middletonii* Thos., Vickery, U. S. D. A., Bur. Ent., Bul. 85, part 6, p. 113, (bio. and notes).
1919 *Aphis middletonii* Thos., Swain, Aphididae of Cal., p. 115, (desc.).
1923 *Anuraphis middletonii* (Thos.), Guyton, Ohio Aphidae, (list).

There is some question as to the validity of this species and it is retained doubtfully. It is listed by Guyton from Ohio, on the roots of *Erigeron canadense*.

Anuraphis viburnicola (Gill.)

Plate I

1909 *Aphis viburnicola*, Gillette, Ent. News, vol. 20, p. 280 (orig. desc.).
1910 *Aphis viburnicola* Gill, Davis, Jr. Ec. Ent., vol. 3, p. 492, (list).
1923 *Anuraphis viburnicola* (Gill), Patch, Hemip. of Conn., p. 298, (list).
1923 *Anuraphis viburnicola* (Gill), Guyton, Ohio Aphidae, p. 14, (list).

This species is commonly found on the foliage of *Viburnum* in spring and autumn. Its full life history is not definitely known but, according to Baker, it, or a closely allied species, has been taken on the roots of various grasses and sedges during the summer months.

Anuraphis persicae-niger (Smith). The black peach aphis

Plates II, V, VI

1890 *Aphis persicae-niger*, Smith, E. R., Ent. Amer., vol. 6, p. 101, (orig. desc.).
1890 *Aphis persicae-niger* Smith, Smith, J. B., N. J. Agr. Exp. Sta. Bul. 72.
1898 *Aphis persicae-niger* Smith, Johnson, Md. Agr. Exp. Sta. Bul. 55.
1908 *Aphis persicae-niger* Smith, Gillette, Jr. Ec. Ent., vol. 1, p. 308, (desc. and fig.).
1908 *Aphis persicae-niger* Smith, Gillette, Col. Agr. Exp. Sta. Bul. 133, p. 37, (bio., control, and fig.).
1915 *Aphis persicae-niger* Smith, Essig, Suppl. Cal. Comm. Hort. Mo. Bul., vol. 4, p. 91, (bio.).
1919 *Aphis persicae-niger* Smith, Swain, Aphididae of Cal., p. 119, (list).
1920 *Anuraphis persicae-niger* (Smith), Quaintance and Baker, Farmers' Bul. 1128, p. 26, (bio.).
1923 *Aphis persicae-niger* Smith, Patch, Hemip. of Conn., p. 295, (list).
1923 *Anuraphis persicae-niger* (Smith), Guyton, Ohio Aphidae, p. 13, (list).

This aphid is commonly taken either from the roots or the twigs of the peach, *Prunus persica*. Due to its color and shape and the fact that it is rarely found on any host except the peach, it is easy to identify. It is widespread thruout the United States, tho its abundance varies greatly in different sections.

It is recorded from two hosts: *Prunus persica,* peach and *Prunus munsoniana,* wild goose plum.

A great many references to the black peach aphis are found in the literature of economic entomology. This might lead one to believe that the species had received much attention. When the literature is investigated, the opposite is found to be the case. Altho fragments of the life history are presented here and there, in no place is a complete account given. However, it is apparent from the limited information that the life cycle varies widely in different parts of the country. The following account is from Quaintance and Baker, Farmers' Bulletin (U. S. D. A.) 1128, and gives the known life history in the eastern states.

"The insect lives thruout the year on the roots of the peach and is most injurious to peach growing on sandy soils. Individuals migrate from the roots during the warm periods in winter or in early spring and start colonies on the twigs and young shoots. In mild climates the insects may exist all winter on the twigs, reproducing during periods of warmth, tho the twigs are for the most part reinfested each year from the insects below the soil.

"The complete seasonal history of this species is not known. The number of young produced by a given parent varies greatly, depending upon weather conditions. Sometimes only one young aphis a day will be produced, with a total of 25 or 30 young to a mother, while under favorable conditions as many as 12 young may be produced in a day and considerably over 100 as the total for a given parent. In spring large numbers of winged forms appear and the percentage of these gradually increases until all of the forms above ground have become winged. These fly to some plant or plants not known and are not met on peach foliage until the next year."

Essig gives the life history in California as follows: "The insect winters over on the roots of the peach trees, where it may also be found in the summer. The first aphids appear above ground very early in the spring and begin attacking the tender leaflets, shoots and suckers, usually those at the base of the tree or nearest the ground. These first plant lice are all wingless. As soon as the buds, young fruit, and leaves appear they are promptly attacked, the entire crop often being entirely ruined. The leaves are curled and weakened, while the young fruit is so distorted as to be killed or rendered unfit for market. During the months of April and May winged migratory females appear, which start colonies on other trees. The work continues until about the middle of July, when most of the lice leave the tops and again go to the roots."

From observations made in Ohio it is evident that the life history here differs somewhat from both the above accounts.

Only one method of overwintering is definitely known, this being on the roots of the peach. At Wooster the writer took living aphids from peach roots at such intervals during the winter that there is no doubt as to this point.

It is entirely possible that there are two other means of overwintering. Many other subterranean species spend the winter in the nests of ants and it is probable that some individuals of this species do the same. Anyone who has worked with this aphid has been struck by the constant attendance of ants upon it. This was noted at all seasons except in the winter when individuals on the roots seemed to be alone. Till the latter part of November the aphids were very numerous in the soil, then suddenly the greater part of them disappeared. No dead bodies remained and it is logical to suppose that the ants took them to their nests, just as has been proved in the case of other aphids. This was observed both at Wooster and Catawba Island. A further argument in favor of this idea is that the aphids appear rather suddenly on the roots in the spring and are always attended by ants. As yet we have been unable to find the lice in ants' nests, so definite proof of this point is lacking.

The possibility of overwintering in the egg stage on an alternate host can not be overlooked. Winged forms appear in the colonies during September and October. With these the writer attempted to start colonies on other peach trees but without success. Further work is planned along this line.

In states with a mild climate, the lice frequently succeed in overwintering in colonies on the twigs. At Wooster, on December 21, 1924, I found over 50 percent of the lice on the twigs still alive. When these were taken into the greenhouse they immediately became active and started reproducing within 24 hours. Up to this date they had undergone temperatures as low as 5 and 7 degrees F. On December 25, a temperature —11° F. killed all lice on the branches.

At any time during the winter a mean temperature of approximately 40° F., lasting over a period of one or more days, permits feeding, and reproduction soon follows. The same temperature relations apply to the starting of activities in the spring. Feeding and reproduction begin regularly in March or April, according to the geographic location and the season. As soon as a colony becomes crowded or other unfavorable conditions arise, ants transfer many of the lice to new feeding positions, often at considerable distances. Other individuals escape the watchfulness of the ants and migrate upward to the twigs of the tree. In this manner aerial colonies are started.

At Catawba Island the migration to the twigs is very slight in proportion to the underground distribution. At other points in the State large numbers of the lice appear on the twigs, which soon become heavily infested. In the aerial colonies, winged forms appear during May and June. It is not definitely known whether these fly to other peach trees or to an alternate host, as yet unknown. It has been my experience that whenever a colony is disturbed, or deprived of the care of ants, or has increased to such an extent that the ants are unable to look after it, that an upward migration occurs. Also in testing the geotrophic reaction of the apterae, it was found always to be negative at ordinary summer temperatures. That is, the lice always crawl up. This movement is aided by the fact that individuals are not repelled by light and are not gregarious to the extent observed in some other species.

Apterous individuals on roots and twigs reproduce at about equal rates if the mean temperature is the same. The average rate of reproduction per day is five, tho I have a record of one louse that produced twelve young in 24 hours. The total reproduction per individual averaged forty under controlled conditions. In the open it is probably somewhat higher. The lice are fully grown and start reproducing in from 8 to 10 days after birth. The first and second instars are each of 1 to 2 days duration, while the last two are 2 to 3 days in length. After becoming adult, the insect in summer lives for about 2 weeks. In autumn individuals live much longer. I have records of several that lived more than 6 weeks after becoming adult, and of one that lived 70 days. As warm weather occurred during November and December a certain amount of reproduction took place, which ceased when the mean temperature fell below 40°. I have no definite record for overwintering individuals, but some must live more than 4 months.

Colonies that were started from single aphids in early June multiplied thruout the summer and winged forms were first noted in early August. They could be found from this time till November 15. The pupae and winged forms (alates) are usually to be found on the underside of the leaves rather than on the twigs. The failure to colonize these forms on peach has been mentioned.

In late July, 1924, an attempt was made to colonize aphids on the tops of uninfested seedlings peaches in a nursery row. Soon after the lice were placed on the tree, ants which were running about over the tree found them and carried them into the soil at the base of the tree. No further attempt was made to infest this nursery row. In October the roots of many of the seedlings were found to be heavily infested and later lice migrated to the tops where thriving colonies were established. It was evident that the ants had established the aphids on the roots and cared for them during this period. In one instance they built a "cow shed" over some aphids that were feeding near the ground. It was noticeable that some colonies of aphids from which ants were excluded did not thrive and several of them died out entirely.

In autumn, despite the appearance and migrating of many alates, the aptera became more numerous, the increase continued till about November 15. From that time till the following spring the numbers were continually on the decrease. Above ground the first individuals to be affected by the cold weather were the first and second instar nymphs. Individuals in the last instar and young adults were quite hardy and many lived for several months.

In summarizing the scattered facts that we have collected, it can only be said that much remains to be done before the black aphis problem is solved.

Genus **Aphis** Linn.

1748 Linnaeus, Syst. Nat., 10th Ed., p. 451

Aphis forbesi Weed. The strawberry root louse

1889 *Aphis forbesi* Weed, Ohio Agr. Exp. Sta., 2, Bul. 6, p. 148 (orig. desc.).
1895 *Aphis gossypii* Glover, Pergande, Insect Life, vol. 7, p. 311 (note).
1901 *Aphis forbesi* Weed, Sanderson, Twelfth Del. Report (complete account).
1908 *Aphis forbesi* Weed, Gillette, Jr. Ec. Ent., vol. 1, p. 178 (note).
1909 *Aphis forbesi* Weed, Smith, J. B., N. J. Agr. Exp. Sta. Bul. 225, p. 24 (bio. and control).
1923 *Aphis forbesi* Weed, Patch, Hemip. of Conn., p. 293 (list).

This aphid was originally described from Ohio where it was at one time a rather serious pest. For several years, however, we have had no reports of this insect. In autumn the eggs of this species are placed on the leaves and about the crown of the strawberry plant. When they hatch in the spring the young aphids are taken underground by ants where they are placed on roots. Here they live and multiply during the summer months.

Pergande (1895) and others have pointed out that this species closely resembles *Aphis gossypii* Glov., the melon aphis.

Genus **Hysteroneura** Davis

1919 Hysteroneura, Davis, Can. Ent., vol. 51, p. 263

Hysteroneura setariae (Thomas). The rusty plum aphis

1877 *Siphonophora setariae*, Thomas, Ill. Nat. Hist. Bul. 2, p. 5 (orig. desc.).
1908 *Aphis setariae* (Thos.), Gillette and Taylor, Col. Agr. Exp. Sta. Bul. 133, p. 41 (bio.).
1910 *Aphis setariae* (Thos.), Sanborn, Okla. Agr. Exp. Sta. Bul. 88 (bio.).
1910 *Aphis setariae* (Thos.), Williams, Univ. Neb. Studies, vol. 10, p. 141 (desc.).
1919 *Aphis setariae* (Thos.), Swain, Aphididae of Cal., p. 124 (list).
1919 *Heteroneura setariae* (Thos.), Davis, Can. Ent., vol. 51, p. 228.
1919 *Hysteroneura setariae* (Thos.), Davis, Can. Ent., vol. 51, p. 263.
1920 *Hysteroneura setariae* (Thos.), Quaintance and Baker, Farmers' Bul. 1128, p. 16 (bio.).
1923 *Aphis setariae* (Thos.), Patch, Hemip. of Conn., p. 297 (list).
1923 *Hysteroneura setariae* (Thos.), Guyton, Ohio Aphidae, p. 15 (list).

The rusty plum aphis is commonly found on the leaves of different species of *Prunus* in April, May, and June. From the plum it migrates to grasses where the summer is spent. In the fall, winged aphids return to the plum. While on grasses the aphids are occasionally found at the base or on the roots of the plants. I have also collected this species from the roots of wild aster, *Aster* sp.

Genus **Rhopalosiphum** Koch

1854 Koch, Die Planz. Aphiden, p. 23

Rhopalosiphum prunifoliae (Fitch). The apple-grain aphis

1855 *Aphis prunifoliae*, Fitch, Nox. and Ben. Insects of N. Y. 1, p. 122 (orig. desc.).
1855 *Aphis mali* Fab. (in part) Fitch, Trans. N. Y. Agr. Soc., vol. 14, p. 753.
1879 *Aphis mali* Fab., Thomas, Eight Ill. Report, p. 85 (desc.).
1886 *Aphis annuae*, Oestlund, Minn. Geol. and Nat. Hist. Sur. 14, p. 43 (desc.).
1901 *Aphis fitchii*, Sanderson, Twelfth Del. Report, p. 137 (desc. and fig.).
1904 *Siphocoryne avenae* (Fab.), Pergande, U. S. Div. Ent. Bul. 44, part 5.
1914 *Aphis avenae* Fab., Davis, U. S. D. A. Bul. 112 (complete acc.).
1917 *Aphis prunifoliae* Fitch, Baker, Science, N. S. vol. 46, p. 410 (syn.).
1919 *Aphis avenae* (Fab.), Matheson, Cornell Memoir 24, p. 750 (complete acc.).
1920 *Rhopalosiphum prunifoliae* (Fitch), Quaintance and Baker, Farmers Bul. 1128, p. 10 (bio.).
1923 *Rhopalosiphum prunifoliae* (Fitch), Patch, Hemip. of Conn., p. 300 (list).

The common apple-grain aphis lives on apple and related plants during the cold seasons of the year and on grasses and cereals during the summer months. On these latter hosts it is frequently found at the base or on the roots of the plants. I also have several definite records of this species overwintering on the roots of wheat. In some fields small areas of wheat were killed; but as the green bug, *Toxoptera graminis,* was also present, we are not sure that the apple-grain aphis was the only causal agent.

Genus **Colopha** Monell

1877 Monell, Can. Ent., vol. 9, p. 102

Colopha ulmicola (Fitch). The cockscomb gall aphid of elm

1859 *Byrsorypta ulmicola,* Fitch, Nox. and Ben.. Insects of N. Y., vol. 5, p. 843 (orig. desc.).
1877 *Colopha ulmicola* (Fitch), Monell, Can. Ent., vol. 9, p. 102 (genus erct. and bib.).
1878 *Colopha eragrostidis,* Middleton, Ill. Nat. Hist. Bul. 2, p. 17 (desc.).
1892 *Rhizobius spicatus,* Hart, Eighteenth Ill. Report, p. 92 (desc.).
1910 *Colopha ulmicola* (Fitch), Patch, Me. Agr. Exp. Sta. Bul. 181, p. 196 (complete acc. and bib.).
1923 *Colopha ulmicola* (Fitch), Maxon, Hemip. of Conn., p. 316 (list).
1923 *Colopha ulmicola* (Fitch), Guyton, Ohio Aphididae, p. 17 (list).

This aphid is found in the cockscomb galls on elm leaves, usually in June. The winged forms fly to grasses where they live on the roots. In autumn there is a return migration to the elm. *Rhizobius spicatus* Hart is the subterranean form of either *Colopha ulmicola* or *Tetraneura graminis*.

Genus **Eriosoma** Leach

1818 Leach, Trans. Hort. Soc. London, vol. 3, p. 60

Eriosoma lanigerum (Haus.). The woolly apple aphis

1802 *Aphis lanigera* Hausmann, Mag fur Insektenkunde hrsg., von Karl Illiger, Bd. 1, p. 440 (orig. desc.).
1903 *Coccus mali*, Bingley, Animal Bib., vol. 3, p. 200 (desc.).
1818 *Eriosoma mali* Sam., Leach, Trans. Hort. Soc. London, vol. 3, p. 60.
1819 *Eriosoma mali* (Sam.), Samouelle, The Entomologist's Useful Compendium, p. 232.
1831 *Myzoxylus mali* (Sam.), Blot, Memoire sur le puceron lanigere etc., In Mem. Soc. Roy. Agr. et de Com. Caen, vol. 3, p. 332.
1841 *Schizoneura lanigera* (Haus.), Hartig, Ztschr. f. Ent., hrsg. v. F. Germar, Bd. 3, p. 359.
1856 *Pemphigus pyri*, Fitch, Nox. and Ben. Insects N. Y., 1, p. 5.
1869 *Eriosoma pyri* (Fitch), Riley, Nox. and Ben. Insects Mo., 1, p. 118 (desc. and fig.).
1912 *Schizoneura lanigera* (Haus.), Patch, Me. Agr. Exp. Sta. Bul. 203 (complete acc. and bib.).
1913 *Schizoneura ulmi*, Woodworth, Univ. of Cal. Agr. Exp. Sta. Cir. 102, p. 4.
1915 *Eriosoma lanigera* (Haus.), Baker, U. S. D. A. Office Sec. Report 101 (complete acc.).
1916 *Schizoneura lanigera* (Haus.), Patch, Me. Agr. Exp. Sta. Bul. 256 (complete).

The woolly apple aphis spends the winter either on the roots of apple and related plants or as eggs on the bark of elm. The eggs hatch in early spring and the young stem mothers seek the opening buds, where their feeding causes the formation of a pseudogall, popularly called "rosette". Winged individuals, arising in these galls, fly to apple, pear, hawthorn, etc., and there establish colonies, either on the branches or on the roots. In this last position they may live many years before winged generations arise that return to the elm. Some individuals, however, migrate to the elm each autumn.

Full accounts of this insect have been published by Patch (1912) and (1916) and Baker (1915).

Genus **Tetraneura** Hartig

1841 Hartig, Germar's Zeitschrift fur die Entomologie, vol. 3, p. 366

Tetraneura graminis Monell

1883 *Tetraneura graminis* Monell, Can. Ent., vol. 5, p. 16 (orig. desc.).
1893 *Tetraneura graminis* Monell, Osborn-Sirrine, Insect Life, vol. 5, p. 237.
1893 *Tetraneura ulmi*, Osborn-Sirrine, Insect Life, vol. 5, p. 237.
1904 *Tetraneura ulmi*, Sanborn, Kan. Aphididae, Pt. 1, p. 23 (desc. and Fig.).
1908 *Tetraneura colophoidea*, Howard, Ent. News, p. 365 (list).
1909 *Tetraneura ulmicola*, Gillette, Jr. Ec. Ent.
1910 *Tetraneura graminis* Monell, Patch, Me. Agr. Exp. Sta. Bul. 181, p. 208 (com. acc. and bib.).
1923 *Tetraneura graminis* Monell, Maxon, Hemip. of Conn., p. 316 (list).

This species produces a cockscomb gall on elm that is indistinguishable from that formed by *Colopha ulmicola*. The habits of the two species, as far as known, are almost identical.

Genus **Pemphigus** Hartig

1837 Hartig, Jahresb. v. d. Fortschr. d. Fortwiss v. forstl. Naturk., vol. 1, p. 645

Pemphigus lactucae (Fitch)

Plates IV, VI

1871 *Rhizobius lactucae* Fitch, Nox. and Ben. Insects N. Y., vol. 14, p. 360 (orig. desc.).
1892 *Tychea brevicornis* Hart, Eighteenth Ill. Rpt., p. 86 (desc. and fig.).
1908 *Tychea brevicornis* Hart, U. S. D. A. Year Book, p. 571 (note).
1912 *Tychea brevicornis* Hart, Sanderson, Insect Pests, p. 331 (note).

Fitch described this species from the roots of lettuce as *R. lactucae*. Hart described it from the roots of various grasses and herbs as *T. brevicornis*. An examination of the types together with a careful comparison of the descriptions leaves no doubt that they are the same. The winged forms of this species place it definitely in the genus *Pemphigus*.

I found this species most abundant on the roots of *Solidago graminifoliae* and *Aster ericoides*. It is a very small, greyish-white louse, usually bearing on the tip of the abdomen a tuft of white wax.

Pemphigus lactucae was collected from the roots of the following hosts.

Grass Family

Agrostis alba L., Redtop
Andropogon virginicus L.
Aristida dichotoma Michx., Poverty grass
Secale cerale, Rye
Triticum vulgare, Wheat

Willow Family

Salix sp. on roots

Buckwheat Family

Polygonum Hydropiper L., Smartweed
Rumex Acetosella L., Sheep sorrel
Rumex sp., Dock

Goosefoot Family

Beta vulgaris, Cultivated beet

Mustard Family

Arabis glabra Bernh., Tower mustard
Arabis laevigata Muhl.
Barbarea vulgaris R. Br., Common watercress
Brassica oleracea L., Cabbage
Brassica sp., Mustard
Lepidum campestre (L.) R. Br.
Radicula Armoracia Rob., Horseradish
Radicula sp., Cultivated nasturtium

Rose Family

Prunus persicae L., Cultivated peach

Pulse Family

Trifolium pratense L., Red clover

Parsley Family

Cicuta maculata L., Spotted crowbane
Cryptotaenia canadensis (L.) DC.

Nettle Family

Lamium Amplexicaule L., Henbit

Composite Family

Aster ericoides L., Wild aster
Aster novae-angliae L., The New England aster
Bidens bipinnata L., Spanish needle
Callistephus chinensis (L.) Nees, China aster, cultivated aster
Lactucae canadensis L., Wild lettuce
Lactuca sativa L., Cultivated lettuce
Senecio aureus L., Golden ragwort
Solidago canadensis L.
Solidago caesia L.
Solidago erecta Pursh.
Solidago graminifoliae (L.) Salisb., Fragrant golden-rod
Taraxacum officinale Weber, Common dandelion

It is possible that *Pemphigus lactucae* may pass the winter in the egg stage on an alternate host. There is some doubt concerning this fact and it will not be discussed further at this time. In any event the great majority of individuals overwinter as wingless adults and nymphs on the roots of various perennial hosts. They may be found scattered in small groups over the entire root system but usually their location is on or near the finer roots. The wax that they excrete from the glands about the distal end of the abdomen is very abundant and frequently they are entirely surrounded by it so that it forms what seems to be a practically water-proof cell. The lice may be located on roots varying in depth from those just at the surface to those below the frost line. It is of interest to note that the lice undergoing the alternate freezing and thawing at the surface survive as well as those not subject to these extremes of temperature.

Little feeding takes place during the winter months, nor is it necessary that food be available if other conditions are normal. This was clearly shown by the following experiment: During the first week of December, 1922, a large number of vials were filled with earth and in each ten to twenty lice were placed. The vials were plugged with cotton and were buried at a depth of six inches in a loamy clay soil. At intervals of one to two weeks during the winter and early spring months these vials were examined. In only one instance did the mortality in the vials seem to exceed that normally taking place in the field where the lice were continually on the roots. In late March, lice taken from the vials were used successfully to start colonies on wild aster and goldenrod roots. In the vials lice were found alive up till May 1, having passed a period of one hundred and forty-four days without food.

Feeding was resumed at any time during the winter or in spring when the mean temperature of the soil averaged about 38 degrees F. for a few days. Limited reproduction occurred at 40 degrees and increased in rapidity as the temperature went up. A mean temperature of 38 to above 40 degrees was reached several times in March and continued with few interruptions during April. Feeding, growth, and reproduction therefore occurred to a limited extent in March but amounted to little in the general life economy of the species till some time in April. This varied according to the season. Feeding and growth of the overwintering nymphs took place at the same time as feeding and reproduction of the adults. In summer the adults reproduced at the average rate of four to five young each day, but in spring this, of course, was less. The adults were highly gregarious. The nymphs migrated soon after birth. This made individual records of reproduction almost an impossibility. Collective counts showed, however, the average number of young to be fairly large, more than fifty at least. A period averaging over seventeen days was required for the nymphs to complete their growth. In common with other aphids there were four instars. The first two were comparatively short and occupied five to seven days, the last two were longer and took the remainder of the period of growth. After reproduction started the adults lived from ten to twenty days. This plus the immature period of seventeen days gave a total length of life of four to five weeks. Temperature entered largely into this, for, as has been shown, some of the overwintering adults lived for five months or more.

The process of birth occupies about twenty minutes. The nymph is born abdomen first, all of the body being extruded in a very few minutes except a small portion of the head. It is then held in this position for ten to fifteen minutes while the legs are unfolded and moved about to harden and gain strength. The head is then released and the young nymph rests for some time before it starts to move about. The young are very elongate, oval in shape, with head, antennae, and legs whitish translucent. The body is the same color but is blotched with lemon-yellow spots. The eyes are composed of three facets and are red. There is no marked division between head, thorax, and abdomen.

Soon after birth the young started an active migration thru the soil in search of suitable food, which, in this case, was the young growing tips of the roots. The nymphs did not locate at the same place on the roots where adults were feeding unless forced to do so by artificial means. I have never found an adult colony in the field that contained young nymphs feeding. This is a departure from the usual behavior of young aphids, which in most cases group themselves about the mother. The very definite migration of the young is also an exception. In their search for proper food I have every reason to believe that these almost microscopic creatures may travel distances of more than a hundred feet. During the night they frequently came to the surface over which they traveled at a rapid rate of speed. In the early morning hours most of them disappeared underground except those that had wandered onto hard surfaces, such as boards, cement walks, etc. I have records of plants ten feet away from the source of infestation that were attacked by the young migrants, and I found individuals at much greater distances than this. If the soil is of such a nature that numerous cracks and crevices exist, the young find their food quite easily. This is the reason that plants in rocky, gravelly, or infrequently-cultivated soil are usually heavily infested.

In 1923 reproduction commenced in the field about April 15 and lasted till late in November. The numbers of lice in the soil increased till about the middle of June when dry weather set in.

From this time until the latter part of August they were not common, altho a few could always be found. This sudden decrease in numbers was not due to a migration, as nothing of this nature occurred. It was due to the fact that the root systems of the hosts, being affected by the dry weather, ceased growth and so failed to furnish the proper food for the young migrants. Only when root growth was normally resumed did the lice again become abundant. This occurred in early autumn and was especially noted in the case of lice on goldenrod roots.

Winged forms appear on the roots in autumn. These have not been collected in Ohio before November, but I have seen a slide of this species, taken by Prof. Herbert Osborn at Ames, Ia., which was dated September 20. At first the winged individuals are rather scarce but increase and reach their maximum abundance about December 1. Alates, together with pupae, were found on roots during the winter till in March. Winged specimens were also taken from a goldenrod plant in a greenhouse which had been kept very dry. Outdoors, alates were not noted during the spring or summer months. Only a small proportion of the lice became winged. At least 95 percent passed the winter as apteras. Due to this fact it is doubtful whether a migration, if such occur, plays any great part in the life economy of the species.

Reactions of *Pemphigus lactucae* (Fitch).—Some time was spent in a study of reactions and various environmental factors as related to this species.

The reaction to light (phototropism) was distinct. The apterous forms, both nymphs and adults, moved away from light toward any dark area. On the other hand the winged forms moved toward light in practically all instances.

The reaction to gravity (geotropism) was not as distinct as that to light but was usually quite clear. The adult apterous forms moved downward in most instances. The young nymphs, however, crawled upward, even light at times failed to stop this reaction. The winged forms moved up or down according to temperature. At above 55 degrees F. they crawled upward, while below 39 degrees the movement was always downward. Between these two temperatures the lice moved either up or down. Temperature greatly influenced the rate of motion, which ceased entirely at 32 degrees F. Above this temperature, activity increased till instant death occurred at 109 degrees F.

The apterous forms are largely dependent on high humidities for their well-being. Normally all interspaces in the soil have the air saturated with water vapor. Lice kept in a humidor with air saturated live much longer than those exposed in open vessels to room humidities, 45 to 65 percent saturation. Some experiments were made with lice kept in sealed jars where the relative humidity was controlled by using various strengths of an aqueous solution of Sulphuric acid (H_2SO_4). These tests are tabulated below:

TABLE 1.—LENGTH OF LIFE IN RELATION TO HUMIDITY

Jar	Humidity	Number of lice	Average length of life
	First test		
Number	*Percent*		*Hours*
1	0	10	15
2	13	8	15
2	83	8	41
4	100	7	48
	Second test		
1	0	10	15
2	13	10	15
3	83	10	52
4	100	10	67

These tests in connection with many other observations show that a high percent of humidity is absolutely necessary for the aphid to live. In connection with from 85 to 100 percent saturation there was observed at all times a marked increase in the activity of the wax glands. Little or no wax was excreted at humidities of from 45 to 75 percent but when this was increased to 85 percent or more, a decided increase in wax production occurred. This was noticed within twelve hours after such a test was started. The whitish pulverescence that covers the entire body, was not noted till two or three days later.

This species is able to stand a considerable degree of submersion. With the temperature ranging from 65 to 75 degrees F. a plant heavily infested, but with roots undisturbed, was placed under water. The lice were still alive at the end of seven days after which the mortality increased rapidly. When lice were taken from the roots, separated from their wax, and placed under water none lived longer than three days.

Tactile reactions (Thigmotropism) are also quite clear in all forms of this species. The individuals prefer to be in a position where they can feel some slight pressure on all sides. The influences of this reaction should be guarded against while testing individuals for other tropisms.

The most interesting and significant fact concerning this species is that it is independent of ants. In other subterranean species dependence on ants is so strong that in many cases the life of the species demands their aid. In this species ants are not necessary and only in a very few instances was any sign of interrelationship noted. Usually the ants ignored *P. lactucae* while they hasted to attend individuals of some other underground form.

Pemphigus populi-transversus Riley. The cottonwood petiole gall

1879 *Pemphigus populi-transversus,* Riley, Bul. U. S. Geol. and Geog. Sur. Terr., vol. 15 (orig. desc.).
1890 *Pemphigus populi-transversus,* Riley, Packard, Fifth Rpt. U. S. Ent. Comm., p. 956 (note and fig.).
1906 *Pemphigus populi-transversus* Riley, Felt, Insects affecting Park and Woodland Trees, vol. 2, p. 633 (note and fig.).
1918 *Pemphigus populi-transversus* Riley, Jones and Gillette, Jr. Agr. Res., vol. 14, p. 577 (complete acc. and figs.).
1923 *Pemphigus populi-transversus* Riley, Guyton, Ohio Aphidae, p. 17 (list).

In addition to the publications given above, this species is mentioned in twenty-five or more other papers. (See Jones and Gillette, 1918). It has been collected in Ohio from *Populus deltoides* and from the roots of *Barbarea vulgaris.*

Genus **Prociphilus** Koch.

1857 Koch, Die Pflanzenlause, p. 279

This genus is represented among the underground forms of Ohio by two species.

Prociphilus tessellata (Fitch). The alder blight

1851 *Schizoneura tessellata,* Fitch, Homop. N. Y. St. Cab., p. 68 (orig. desc.).
1879 *Pemphigus acerifolii,* Riley, Bul. U. S. Geol. and Sur. Terr. 5, 1, p. 16 (desc.).
1908 *Pemphigus tessellata* (Fitch), Jackson, Proc. Col. Hort. Soc., pp. 183-209 (list).
1911 *Pemphigus tessellata* (Fitch) *(acerifolii)* Patch, Me. Agr. Exp. Sta. Bul. 195, p. 244 (complete acc. and bib.).
1918 *Prociphilus tessellata* (Fitch), Patch Me. Agr. Exp. Sta. Bul. 270, p. 45 (note).
1923 *Prociphilus tessellata* (Fitch), Guyton, Ohio Aphidae, p. 18 (list).

The woolly colonies of this aphid are common on alder in summer and autumn. In September and October winged individuals arise that fly to maple where the winter is passed in the egg stage. Many of the young nymphs overwinter at the bases and on roots of alder bushes. Winged forms from the maple return to alder in May and June.

Prociphilus erigeronensis (Thomas). The white aster root louse

Plates III, IV

1879 *Tychea erigeronensis* Thomas, Eighth Ill. Report, p. 168 (orig. desc.)
1892 *Trama erigeronensis* (Thomas), Forbes, Eighteenth Ill. Rpt., p. 82 (desc. and fig.).
1918 *Prociphilus erigeronensis* (Thomas), Patch, Me. Agr. Exp. Sta. Bul. 270 (note and figs.).

Prociphilus erigeronensis is most commonly found on the roots of different Compositae, especially the asters, both wild and cultivated. Its color is white and its shape a short oval. Six longitudinal rows of wax glands are to be found on the body. Two are located laterally, one on either side, while the other four are dorsal. The lateral glands can always be located by definite extrusions of wax, but those on the dorsal surface are harder to find. It is sometimes necessary to place individuals in a container where the air is saturated with water vapor. This causes the appearance of wax and the glands can be accurately placed. At times this species is a serious pest of cultivated asters and has been known to destroy large plantings.

This aphid was collected from the nests of ants, (*Lasius umbratus*, subspecies *mixus,* var. *aphidicola* Walsh.), and from the roots of the following hosts.

Grass Family

Agrostis perennans (Walt.) Tuckerm, Thin grass
Danthonia spicata (L.) Beauv., Wild oat grass
Muhlenbergia Schreberi J. F. Gmel, Drop seed
Poa pratensis L., Ky. blue grass
Spartina sp., Marsh grass
Triticum vulgare L., Wheat

Rush Family

Juncus effusus L., Common rush

Buckwheat Family

Polygonum Hydropiper L., Smartweed

Goosefoot Family

Beta vulgaris, Cultivated beet

Mustard Family

Capsella Bursa-pastoris (L.) Medic., Shepherds purse

Rose Family

Rubus allegheniensis Porter, Blackberry

Pulse Family

Phaseolus vulgaris L., Cultivated bean
Trifolium hybridum L., Alsike clover
Arachis hypogaea, Peanut

Maple Family

Acer saccharinum L., Silver maple

Mint Family

Glecoma hederacea L., Ground ivy

Nightshade Family

Locopersicon esculentum Mill., Tomato

Broom-rape Family

Epifagus virginiana (L.) Bart., Beech drops

Composite Family

Ambrosia artenisiifolia L., Ragweed
Aster ericoides L., Wild aster
Aster novae angliae L., The New England aster
Bidens bipinnata L., Spanish needle
Callistephus chinensis (L.) Nees, China aster, cultivated aster
Lactuca sativa L., Cultivated lettuce
Solidago graminifoliae (L.) Salisb., Fragrant golden-rod
Solidago canadensis L.
Tragopogon parrifolius L., Salsify
Xanthium commune Britton, Cocklebur

Experiments showed that this species may pass the winter in at least two days. First and most commonly in the nests of ants, usually *Lasius umbrates*, but possibly other species as well. In the late autumn of 1922 a large number of wild asters, *Aster ericoides* L., which were infested by this aphid were dug and brought into a cold insectary. Here some were planted in pots and some in glass cages where the colonies could be observed. As many ants as possible were collected with each colony and transplanted with it. During the last week in November it was noted that the ants were forming a nest near the bottom of one of the glass cages. Into this nest they brought numerous aphids from the roots of the plant and placed them usually on the walls of the cavity where they remained motionless for long periods. This colony of ants was very weak and a rise in temperature during January gave the aphids a chance to wander away from their disorganized attendants. Several of the plants in pots had stronger groups of ants and these successfully overwintered the aphids till in March and April. Soon after this the aphids were placed on roots to feed.

The species can also overwinter alone in the soil. On October 9, 1924, a large number of aphids were collected from aster roots and placed in vials of moist earth. These vials contained no food and each was securely plugged with cotton. After cooling they were placed in a 32-degree F. cold storage room. At intervals of two weeks during the winter months vials were inspected and in all cases a majority of the aphids were alive. On March 5 the last vial was examined and in it five out of ten lice were alive. In another lot of vials kept in a 40-degree room for four weeks before being placed in the 32-degree storage, the mortality was uniformly higher, tho on March 12 one louse was still alive.

Feeding and a very limited reproduction occurred when the mean soil temperature was at 40 degrees. This was determined as follows: Wingless adults were placed in vials of moist earth which were kept in a 40-degree cold storage room for 24 hours. The vials were then examined, all young removed, and the adults replaced. At the end of another 24-hour period under the same storage conditions the vials were reexamined. In several instances a few young were found, showing that reproduction may take place at a mean temperature of 40 degrees. The optimum temperature for reproduction is not known. From several experiments it is known that the presence of ants is essential for normal reproduction.

From field observations it appeared that reproduction of any consequence does not occur before the last week of April or during the first ten days in May. This variation took place according to the season. On May 10, 1924 (a very late season) some lice were still to be found in ant nests tho most were on roots with a few nymphs present.

The records of reproduction and length of instars are incomplete. This is due, in large part, to the fact that individuals are so dependent upon ants. When ants were placed with aphids in a position where all could be observed, they shifted the aphids about so that it was impossible to keep track of individuals. When no ants were used the aphids refused to act normally. One nymph that was observed lived six weeks, but, in this length of time, did not moult nor show any evidence of growth. Many similar cases in which the lice did not live so long were observed. Usually lice, when placed on roots, remained from one to ten days, apparently without any change, after which they wandered off into the soil and were lost. Field observations lead us to believe that the nymphal period requires from fifteen to eighteen days. Under laboratory conditions in summer, adults lived as long as three weeks. Some of the overwintering forms must live at least five months.

Despite the fact that normal reproduction starts in May, the species does not become abundant till in August or September. At this time the roots of favorite host plants are to be found literally covered with colonies of aphids. These are attended usually by *Lasius umbratus,* subspecies *mixus,* var. *aphidicola* Walsh, or *Lasius niger,* subspecies *alienus* Forster, var. *Americanus* Emery. Other species of ants may occasionally be noted in attendance. *Lasius niger* will steal aphids from colonies of *Lasius umbratus* if opportunity permit. At one time an infested wild aster plant, with the latter species of ant attending the aphids, was brought into the insectary and placed near a colony of *Lasius niger.* In a few hours members of the two colonies were observed fighting while unengaged individuals of *L. niger* were rapidly transferring the aphids to their nest. Here they were found later, colonized on the roots of another aster.

Most of the cultivated asters are killed by frost in October and the aphids are soon after removed to the roots of perennials. Here they live till late November when they are taken from the roots to the nests of the ants.

Very rarely a winged form may be found during the autumn months. The conditions under which these arise are as follows: At times an aphid colony may increase to such numbers that the ants are unable to look after all individuals. The host plant may die from the aphid attack or from other causes and the ants not be able to move all the lice to a new host. Some of those left on the roots remain feeding and from these a few winged individuals develop. In all cases where alate forms were found, one or both of these conditions existed. Winged forms were also obtained from pupae that had been collected and were kept in moist earth with pieces of roots. The pupae were easily separated from the apterous forms by the short, tightly-curled threads of wax from the glands. This differs greatly in appearance from the usual short tufts.

The most important facts in the life history of the species are as follows:

Genus **Forda** Heyden

1837 *Forda* Heyden, Mus. Sinkgb., vol. 2, 291

Key. Antennae of both alate and apterous forms with numerous fairly prominent hairs ....*formicaria* Heyden
Antennae without such hairs ....*olivacea* Rohwer

Forda formicaria Heyden

1837 *Forda formicaria* Heyden, Mus. Sinkgb., vol. 2, p. 292 (orig. desc.).
1894 *Forda occidentalis* Hart, Eighteenth Ill. Report, p. 84 (desc. and fig.).
1913 *Forda occidentalis* Hart, Swenk, Nebr. Ent. Bul. 1, p. 83 (bio.).
1918 *Forda formicaria* Heyden, Gillette, Ent. News, vol. 29, p. 283 (bio. and syn.).

This species has not been reported from Ohio, but should be found within the limits of the State. It feeds on roots of grasses and is attended by ants.

Forda olivacea Rohwer

Plate III

1908 *Forda olivacea* Rohwer, Psyche, vol. 15, p. 68 (orig. desc.).
1918 *Forda olivacea* Rohwer, Gillette, Ent. News, vol. 29, p. 281 (bio. and fig.).
1923 *Forda olivacea* Rohwer, Guyton, Ohio Aphidae, p. 18 (list).

Forda olivacea is usually found on the roots of grasses and cereals, where it is constantly cared for by ants. It has been collected only rarely in Ohio.

Genus Geoica Hart

1892 *Geoica* Hart, Eighteenth Ill. Report, p. 89. Type (mono-typical) *Geoica squamosae* Hart.

Geoica squamosae Hart

Plate IV

1892 *Geoica squamosae* Hart, Eighteenth Ill. Report, p. 90 (orig. desc. and fig.).
1911 *Geoica squamosae* Hart, Swenk, Neb. Ent. Bul. 1, p. 83 (note).
1920 *Geoica squamosae* Hart, Baker, U. S. D. A. Bul. 826, p. 79 (class. and figs.).
1923 *Geoica squamosae* Hart, Maxon, Hemip. of Conn., p. 318 (list).
1923 *Geoica squamosae* Hart, Guyton, Ohio Aphidae, p. 18 (list).

Geoica squamosae is a white, pear-shaped, louse whose body, head, and appendages are armed with broad, slightly curved squamae. A microscope is required for a definite determination. It occasionally becomes of economic importance because of its attacks on the roots of wheat. Plants of the grass family are its usual hosts as is shown by the following list.

Host plants of *Geoica squamosae* Hart

Grass Family

Agrostis perennans (Walt.) Tuckerm., Thin grass
Avena sativa, Cultivated oats
Danthonia spicata (L.) Beauv., Wild oat grass
Muhlenbergia mexicana (L.) Trin., Satin grass
Panicum crusgalli L., Barnyard grass
Phleum pratense L., Timothy
Poa pratensis L., Ky. Blue grass
Setaria viridis (L.) Beauv., Foxtail
Triticum vulgare, Wheat
Zea mays, Corn

Rush Family

Juncus sp.

Mustard Family

Capsella Bursa-pastoris (L.) Medic., Shepherds purse

Pulse Family

Trifolium pratense L., Red clover

Composite Family

Aster ericoides L., Wild aster
Solidago graminifolia (L.) Salisb., Fragrant golden-rod

This aphid is constantly attended by ants and is dependent on them for overwintering and the location of food. Winged forms may be found at times, but their part in the life cycle has not been determined.

Geoica radicola (Essig)

Plate IV

1909 *Pemphigus radicola* Essig, Pom. Jr. Ent., vol. 1, p. 8 (orig. desc.).
1909 *Trifidaphis radicola* (Essig), Del Guercio, Riv. dipatal. veg. vol. 3, p. 20 (erection of genus).
1909 *Trifidaphis radicola* (Essig), Baker, Pom. Jr. Ent., vol. 1, p. 74 (trans. of above).
1912 *Trifidaphis radicola* (Essig), Pom. Jr. Ent., vol. 4, p. 699 (list).
1913 *Trifidaphis radicola* (Essig), Cal. Hort. Bul. II, vol. 1-2, p. 58 (note).
1919 *Trifidaphis radicola* (Essig), Swain, Aphididae of Cal., p. 141 (list-note).
1923 *Trifidaphis radicola* (Essig), Maxon, Hemip. of Conn., p. 319 (list).
1920 *Geoica radicola* (Essig), Baker, U. S. D. A. Bul. 826, p. 79 (class.).

This species is a large, globose, pinkish louse whose body is usually covered with a light coat of white, powdery wax. In Ohio it is frequently found on the roots of beans, which it occasionally injures to an appreciable extent.

Essig (1909) described this species as a *Pemphigus*. Del Guercio, in the same year, erected the genus *Trifidaphis* for it. Baker (1920) considers that it belongs to *Geoica* and the writer agrees with him.

The grass family seems to be free from the attacks of this insect. It has been collected from the following hosts.

Nightshade Family

Solanum douglasii
Solanum tuberosum L., Potato

Pulse Family

Lathyrus odoratus Cupani., Sweet pea
Phaseolus vulgaris Linn., Cultivated bean

Dog-bane Family

Vinca minor Linn. var. *alba variegata* Hort., Periwinkle

Heath Family

Vaccinum macrocarpon Ait., Cranberry

Amaranth Family

Amaranthus retroflexus L., Pigweed

Composite Family

Aster ericoides L., Wild aster
Solidago graminifolia (L.) Salisb., Fragrant golden-rod

Only one method of passing the winter is definitely known, this being as apterous individuals on the roots of perennial plants. They were collected during the winter and in March from hosts such as *Aster ericoides* and *Solidago graminifolia.* In these positions they were at times, tho not always, attended by ants. The species was taken from the nests of *Lasius niger* in November which was the only indication that the aphids may overwinter in this manner. They failed to overwinter in vials filled with earth, but without food, tho some individuals lived 50 days or more. These vials were kept at freezing temperatures during the period of the tests.

Reproduction took place at a lower mean temperature than was found for other subterranean species. Slight reproduction occurred at 36 and 37 degrees F., while at 40 degrees it was of such amount as to be of importance in the life cycle. At the last named temperature, and without food, reproduction continued for a period of at least a month. At the same temperature the young nymphs lived from two to three weeks without food.

In summer from 9 to 13 days were required for the nymphal period. Reproduction followed shortly after the insect became adult. The apterous adults that were observed in the laboratory lived an average period of 16 days, about half of which was taken up with active reproduction. A few of the first-instar nymphs settled and fed on the same root as the mother, but most of them wandered off into the soil in search of fresh food.

July 4 was the earliest date of collection from bean roots. The condition of the colony, however, clearly showed that infestation had taken place in mid June. Beans were usually infested till they were killed by frost. Thru the remainder of the year the species was taken only from the roots of perennials or from greenhouse plants, such as sweet peas and the variegated periwinkle. In greenhouses ants were always found in attendance but in the field colonies were at times found that seemed independent. The latter usually contained only a few individuals and seldom attained much size.

Winged forms were frequently met with during the summer and autumn; but no alternate host was found, nor was any definite migration to new hosts of the same species noted.

CONTROL OF SUBTERRANEAN APHIDS

It is the purpose of this section of the publication to present—First, the results of experimental control work against the white aster root louse, *Prociphilus erigeronensis* (Thos.), and the black peach aphis, *Anuraphis persicae-niger* (Smith); Second, to summarize briefly the best known and most practical remedies that may be used against this group of aphids.

Experimental Control Work Against the White Aster Root Louse, *Prociphilus erigeronensis* (Thos.)

The different materials that were used as control agents against this aphid were applied at different times during the growing season and in different amounts. The manner of application varied according to the remedy. In general the liquids were poured about the roots after the earth had been pulled away from the base of the plant. Dry materials were usually dug into the soil around the plant. The materials employed and the results following their use were as follows:

Calcium cyanide ($Ca(CN)_2$).—This material when brought in contact with normal atmosphere moisture gives off hydrocyanic acid gas which is a deadly poison and a most effective insecticide. The chemistry of this reaction is according to the following formula:

$$Ca(CN)_2+2H_2O=2HCN+Ca(OH)_2$$

If the air be saturated with water vapor part of the hydrocyanic acid gas (HCN) will pass over into ammonia.

$$2HCNO+2H_2O=2NH_3+2CO_2$$

This may occur if the material is put into the soil soon after a rain, which means that the gas can not penetrate as far thru the soil before it is broken down as it can with the soil dry.

Calcium cyanide was used in both flake and granular form after asters were found infested. Individual plants were used and in all cases these were full grown and in bloom. The calcium cyanide was either scattered in a ring about the plant and then covered with earth (in the same manner as paradichlorobenzene is used against the peach tree borer) or placed in a hole directly beneath the roots. Applications were made with the soil both wet and dry, but this difference seemed to have little effect on the plants. Amounts of five grams or more killed the plants in two or three days, while two to four grams severely injured them. The manner of application made little difference in this respect. The above amounts usually killed the lice before the plants showed much injury. Amounts of one gram placed underneath the plant killed numerous aphids without noticeably injuring the plant. This treatment may have some value but further work is needed before it can be recommended. The very small amount that must be used to safeguard the plant makes its practical application rather difficult.

Carbolineum avenarius.—Sawdust was saturated with this material and one ounce (about three heaping tablespoonfuls) was dug in about the base of the plant. This dosage killed young asters and severely injured old plants in from two to seven days. Little effect was noted on the aphids.

Carbon bisulphide.—Aster plants just coming into blossom were treated with this material, using 10, 5, and 2½ cc. per plant. A small hole was made in the soil near the plant and the carbon bisulphide poured into it, after which the opening was closed. An application of 10 cc. injured the plants noticeably; 5 cc. caused only slight damage, and no effects could be seen from the 2½ cc. treatments. Unfortunately no aphis infestation developed on the checks for this experiment, so we were unable to determine its effects on aphids. Persons growing asters who have used carbon bisulphide do not report favorable results, as it either killed the plants or failed to free them from aphid attack.

Carbon bisulphide emulsion.—This emulsion was made according to the formula of the United State Department of Agriculture, which is as follows:

Resin fish-oil soap	12.5 grams
Water	87.5 cc.
Carbon bisulphide	250. cc.

The soap is dissolved in hot water, which is then permitted to cool. The carbon bisulphide is added and the mixture agitated violently until a white, creamy emulsion is formed. Twenty cc. of this stock emulsion was used to a gallon of water, and a pint of this solution poured about the roots of each plant. No injury to the plants was noted but the aphis infestation was so light that it was impossible to get positive results. Further work with this material is in progress.

Corrosive sublimate.—A solution of 1 ounce of the powder to 4 gallons of water was poured about the base of the plants, at the rate of 1 to 2 pints to each plant. All plants were damaged to an appreciable extent. No effect was noted on a light infestation of aphis.

Nicotine sulphate.—Nicotine sulphate of a strength of 1 teaspoonful to a gallon of very soapy water was used. The earth was pulled away from the base of the infested plant and from 1 pint to 1 quart of this solution poured about the roots. Numerous aphids were killed by this treatment but applications had to be repeated several times during the season to secure the best results. We have never seen plants that were injured by this treatment. At present this is one of the most practical methods of control for use in small plantings of asters. The first application should be made when aphids or damage is first noted.

Paradichlorobenzene.—From 5 grams to 1 ounce of this material was used in treating individual plants. The application was made in the same manner as for the peach tree borer. At first no injury was noticed but in about two weeks the plants wilted and soon after died. Amounts of 5 grams caused injury almost as severe as that of 1 ounce. The material is toxic to aphids but cannot be used safely until further work has determined the amount that will not harm the plant.

Sulphur.—One-fourth pound of ground sulphur, dug in about the roots of the plant, did no damage, but no killing of aphids was secured. (See page 220 for a more detailed discussion of sulphur).

Tobacco dusts.—Both coarse and finely-ground dusts were dug in about the roots. The amounts used were from ¼ to ½ pound per plant. Despite the wide use and recommendation of this material it proved ineffective in our tests for the control of the white aster root louse.

Experiments Against the Black Peach Aphis, *Anuraphis persicae-niger*, (Smith)

Control work against this aphid was conducted in newly set peach orchards, most of it being done in an orchard composed largely of seedling trees that was set especially for this purpose.

These orchards were located in Catawba Island Township, Ottawa County. The land for them was supplied by Mr. A. P. Palmer of Port Clinton, Ohio, to whom the writer is greatly indebted for many courtesies and much material assistance.

The orchard is located on a gravelly ridge and the land had formerly been set to peaches. As the old trees died, great difficulty was experienced in establishing a new orchard. Old peach trees were located to the east and north of this site. The surface soil is sandy with a large admixture of gravel and small stones. The subsoil is a red clay. It has frequently been noted that only on soil of this nature is the black peach aphis a serious problem. Here they attack the young trees and in combination with other factors, cause a high mortality. This soil is also easily depleted of its fertility and organic matter and quickly gets into poor physical condition. For this reason the land had been kept in sweet clover for several years before the experimental work was started. Many of the seedling trees were set in old orchard soil that had not been in legumes but had received cultivation up to the time of planting. Of the check trees planted in the old orchard soil 20 percent failed to live thru the first summer. Of the checks in the soil that had been in sweet clover only 8 percent failed to grow. As the number of checks exceeded 150 trees the difference of 12 percent is significant and shows the advantage of planting on renovated soil.

The experiments are divided into three groups according to the time of treatment.

First series	Materials used before planting
Second series	Materials used at planting
Third series	Materials used at first signs of aphid attack

1. Materials used before planting

In the autumn of 1923 two ounces of calcium cyanide was used to treat each of ten holes where trees were set in April, 1924. Six of the ten trees died during the summer of 1924 and the others were very weak. No aphis infestation was noted, but from the condition of the trees it appears that this treatment cannot be used.

At the same time each of four tree holes was treated with 2 pounds of coarse tobacco dust, which was dug into soil in the hole. Of the trees planted in the treated holes, one died during the summer and one was very weak. There was no infestation on the living trees nor on the checks, so the results are inconclusive.

2. Material used at time of planting

In this series of treatments all the trees used were one-year-old seedlings. They were set April 15, 1924, in soil that had been in sweet clover for several years. On the day of planting the temperature ranged between 50 and 60 degrees F. and the soil was moist.

Tobacco dust.—Ten trees were treated with finely-ground tobacco dust, five receiving 2 pounds each and five 1 pound each. This material was dug into the soil in which the tree was set. Of the ten trees, seven died and the other three were not vigorous. Aphids were found on one of the living trees. The death of so many of these trees was probably due to a poor mixture of the dust with the soil so that capillarity was destroyed and the roots failed to get the needed moisture. It was also ineffective against aphids.

Paradichlorobenzene.—Ten trees were each treated by having 1 ounce dug into the soil in which the trees were set. All of these trees were dead by July 23.

Scalecide, 1-15.—Five trees were treated by pouring 1½ gallons of the dilute solution about the roots of the tree as it was being planted. All trees were dead by August 1.

Home-made engine oil emulsion, 1-33.—The dilute solution was used at the rate of 1½ gallons per tree in the same manner as Scalecide. Five trees were treated, of which one died. Two of the living trees were infested with aphids.

Sulphur.—(See notes under third series).

The results with all remedies used at planting time were unfavorable.

3. Materials used at time of aphis attack

Control measures of this nature were conducted in 1923 and 1924 and are being continued in 1925. The applications were usually made about the middle of June.

In 1923, treatments of tobacco dusts, dilute nicotine sulphate, paradichlorobenzene, and carbon bisulphide were applied on a young commercial peach orchard. Carbon bisulphide killed several trees. No injury was caused by the other materials. As no aphis infestation developed on the checks, no results were secured.

In 1924, extensive trials of various materials were made on a young orchard of seedling peaches. All of the trees were set in the soil that had recently been in sweet clover. The applications were made June 9 and 10, 1924; temperature averaged 70° F., and the soil was moist following recent rains. The materials used, amounts, manner of application, and results are given below.

Calcium cyanide.—The granules were scattered in a ring about the tree and then covered with earth. Five trees each received ¾ ounce. Of these, three were weakened. Eighteen trees received ⅜ ounce. Three died and three were weakened. No lice were found on the living trees; but, as check trees were also uninfested, the effectiveness of this material is in doubt.

Carbon bisulphide.—Thirteen trees were treated by pouring 10 cc. (about 2 teaspoonfuls) in a small hole near the base of the tree. The hole was then filled with earth. Eight of these trees died and three more were weakened. Nine trees each received 20 cc., applied in the same manner. Of these, five died and one was in poor condition. No lice were found on the living trees. These results confirm our belief that carbon bisulphide can not be used safely on peach trees.

Carbon bisulphide emulsion—(Made as described on p. 215).—Ten trees each received 1 gallon of a dilute solution which was made by pouring 200 cc. (½ pint) of the stock emulsion into 10 gallons of water. Five trees died and one of the living trees was infested.

Ten other trees each received 1 gallon of solution made by using 100 cc. of the stock emulsion to 10 gallons of water. Four trees died and four others were injured. There was no aphid infestation.

Nine trees each received 1 pint of a solution made by placing 200 cc. of stock in 2 gallons of water. Four trees died and four others were weakened. The living trees and checks were not infested. These results show definitely that this material can not be used with safety.

Corrosive sublimate—1 ounce to 10 gallons of water.—Ten trees each received a gallon of this solution poured about the roots. No trees died; one was found infested with aphids. Two trees each received 1 gallon of water in which ½ ounce of corrosive sublimate had been dissolved. Both trees were killed. Heavy doses were unsafe while light doses were ineffective.

Nicotine sulphate.—A solution consisting of 4 teaspoonfuls of 40 percent nicotine plus 8 teaspoonfuls of stock engine oil emulsion to 1 gallon of water was poured about the roots in amounts varying from 1 pint to 1 gallon. None of the trees were injured, nor was there any aphid infestation. However, check trees for these rows were likewise uninfested so that this result was indefinite.

Oils.—**Sunoco oil,** 1-30, was poured about the roots at the rate of 1 gallon per tree. Eight trees were treated, of which four died during the summer. The living trees and their checks were uninfested. **Rex oil emulsion,** diluted 1-33, was used in the same manner and amount as above. Five trees were treated, all of which lived. There was no infestation on them nor on the checks.

Oil of tansy, ½ ounce to 1 gallon of water, was poured about the roots of the trees in varying amounts. The trees were uninjured. No results were obtained due to lack of infestation on the checks.

Paradichlorobenzene.—Fifty-five trees were treated by placing the material in a ring about the tree and then covering it with earth. Amounts varying from ¼ to ¾ ounce were applied. Of all the trees so treated none showed aphid infestation, while many of the checks had lice in numbers. Casual observation seemed to show that even the heavier doses had not injured the trees. A close study of the trees and compiled data give the following result:

55 treated trees, 13 or 24 percent, dead or weak
70 untreated trees, 12 or 17 percent, dead or weak

In the plots treated with ½ and ¾ ounce the greatest number of dead and weak trees were found. It is believed that doses of ¼ to ⅓ ounce can in most cases be safely used and that this treatment is one of the most promising in view.

Sulphur.—In cooperation with Dr. J. W. Bulger of Ohio State University, tests of sulphur applied in three different ways were made. In test I six trees were used and the sulphur was applied in amounts of 1 to 16 pounds per tree at the time of planting. The material was dug into a space of about four square feet surrounding the base of each tree. All trees so treated were dead by July 12. Hydrogen-ion determinations of soil samples taken during the season were made by Dr. Bulger. These are shown in table 2.

TABLE 2.—HYDROGEN-ION DETERMINATION OF SOIL IN SULPHUR EXPERIMENT, TEST 1

Dates and amounts of applications

Tree	Sulphur applied	Hydrogen-ion determination				
		April 8 before treatment	June 9	July 12	August 30	October 6
No.	*Lb.*	PH	PH	PH	PH	PH
1	1	6.3	4.5	2.9	3.8	5.7
2	2	6.3	4.1	2.7	3.6	3.9
3	4	6.2	4.3	2.6	3.4	3.8
4	6	6.3	4.8	2.8	3.9	3.8
5	10	6.2	4.8	2.6	3.9	3.9
6	16	6.2	4.8	2.6	4.7*	6.2

*Small soil sample.

In a second experiment sulphur was mixed with fresh manure to secure a reducing action. $S+O_2=SO_2 \rightleftarrows H_2SO_4 \rightleftarrows H_2S+O_4$. It was thought that the H_2S might have some insecticidal value if produced in any quantity. This mixture was dug in about the base of the tree as in the first experiment. The treatments were applied June 9. The rates of application, the hydrogen-ion determinations, and the results are shown in table 3.

TABLE 3.—HYDROGEN-ION DETERMINATION OF SOIL IN SULPHUR EXPERIMENT, TEST 2
Dates and amounts of applications

Tree	Treatment		Hydrogen-ion determination				Condition of tree October 6
	Manure	Sulphur	June 9 before treatment	July 12	August 30	October 6	
No.	*Gal.*	*Lb.*	PH	PH	PH	PH	
1	1	½	6.3	5.6	6.8	7.1	dead
2	1	3	6.3	4.4	6.8	7.1	dead
3	1	none	6.3	6.6	7 0	7.0	living
4	1	6	6.3	3.3	6.4	7.2	dead
5	2	½	6.3	6.4	7.0	7.2	living
6	2	none	6.3	6.6	7.0	7.0	dead
7	2	3	6.3	4.5	7.0	7.1	dead
8	2	6	6.4	4.5	7.0	7.0	dead

With the rapid loss of acidity in August and September it is hard to understand why so many of these trees should have died.

In the third experiment varying amounts of sulphur were applied to the trees at two times during the summer, first on June 9 and second on July 23. The amounts applied each time, the hydrogen-ion determination, and the results are shown in table 4.

TABLE 4.—HYDROGEN-ION DETERMINATION OF SOIL IN SULPHUR EXPERIMENT, TEST 3

Tree	Sulphur applied	Hydrogen-ion determination				Condition of tree October 6
		June 9 before treatment	July 12	August 30	October 6	
No.	*Lb.*	PH	PH	PH	PH	
1	½	6.0	6.2	6.3	6.2	living
2	1	6.4	6.2	5.7	6.0	living
3	none	....	6.9	7.0	6.8	living
4	3	6.5	6.4	5.8	5.0	living
5	6	6.5	6.2	6.2	5.7	dead

Aphids were found on one of the living trees. This with the high mortality of treated trees shows that sulphur can not be used as a control for the black peach aphis.

Tobacco dust.—Twenty-eight trees were treated with a finely-ground, fresh, tobacco dust applied at the rates of ½ and 1 lb. per tree. It was carefully mixed with the soil at the base of the tree. Seven of the treated trees were examined, of which four were found infested. One colony of aphids was apparently flourishing surrounded on three sides by damp dust. These and other results show that this much used remedy can not be relied on to control the black peach aphis.

Ustin, 1-10.—A gallon of this solution was poured about each of three trees, all of which died. No data were secured as to its effect on the aphids.

Venetan, 1-50.—One gallon of this solution was poured about the roots of each of four trees. One of these died and the others with their checks were uninfested.

RECOMMENDED CONTROLS

Of the twenty-one species of aphids that have been found in subterranean habitats in Ohio, several are of great economic importance and at times it is necessary that control measures be used against them. These species are: The corn root louse, *Anuraphis maidi-radicis* (Forbes); the black peach aphis, *Anuraphis persicae-niger* (Smith); the strawberry root louse, *Aphis forbesii* Weed; the woolly apple aphis, *Eriosoma lanigerum* (Haus.); and the white aster root louse, *Prociphilus erigeronensis* (Thos.). Other underground species may at times become injurious, but the above are the chief offenders. Due to differences in habits and hosts the control measures are somewhat different for each species.

The corn root louse.—This species attacks several plants, of which corn suffers by far the greatest injury. The controls for this aphid may be detailed as follows:

1. The practice of any standard crop rotation. Usually, if this is faithfully followed, other controls are unnecessary.
2. Early spring plowing followed by repeated disking to break up the nests of ants and to destroy the food plants on which the aphids feed till corn begins to grow.
3. Cooperation in the use of the above measures in localities where the louse is troublesome.
4. If it has not been possible to carry out the above measures, use a repellent. Such can be made by mixing ¼ pound of oil of tansy with 1 gallon of wood or denatured alcohol. Mix this solution with one hundred pounds of fertilizer and plant with the corn. It should be applied at the regular rate of fertilizer application.

See the white aster root louse for control in case the corn root louse is found on asters.

The black peach aphis.—No definite control for this species is known, but several things may be done to alleviate the damage.

1. In case the black peach aphis is known to be present, do not plant peaches on sandy, gravelly, or stony soil that may be used for other crops.

2. Renovate the old orchard soils by growing several crops of legumes, such as sweet clover, alfalfa, or soybeans. Get the soil into good physical condition and increase the fertility.

3. Plant trees that are free from this insect. If there is any doubt as to this point, dip the trees in a strong nicotine sulphate and soap or oil emulsion solution.

4. Paradichlorobenzene may be applied at the rate of ¼ to ⅓ ounce per tree when aphis work is first noted. This material should be placed in a ring about the tree, not touching the trunk, and covered with earth.

If aphids appear on the tops of the trees they can be controlled by spraying with the following solution:

Nicotine sulphate 40 percent	¾ pint
Soap	4 pounds
or	
Stock oil emulsion	½ gallon
or	
Miscible oil (see package directions)	½ gallon
Water	100 gallons

For dipping use only 50 gallons of water and the remainder of the formula as above. For a small amount of spray use 1 teaspoonful of nicotine sulphate to 1 gallon of very soapy water.

The strawberry root louse.—At one time this aphid inflicted considerable loss on strawberry growers in Ohio. At present it is rarely found. In case of trouble the following controls are recommended:

1. If lice are present do not keep the strawberry planting in the same place.

2. Plow early and cultivate frequently land that is to be set in strawberries. This destroys the ant nests.

3. Set out uninfested plants. If there is a possibility of lice being on the plants, dip them in a nicotine-soap solution.

4. Put the new beds at some distance from infested plantings.

5. In the spring just after the aphids have hatched many may be destroyed by scattering a light coat of straw over the infested bed and burning it. This should be done before growth starts.

The woolly apple aphis.—This severe pest of the apple may be attacked in several ways. However, after it is located on the roots of a tree, its eradication is practically impossible.

1. If possible do not plant trees that show the aphis galls or swellings on the roots.

2. Dip in a nicotine-soap solution all trees that might have living aphids on roots or tops. Trees that have been fumigated are usually free from aphis.

3. In nurseries where root grafting is practiced the roots should be treated to insure freedom from aphids. The stock should then be set at some distance from infested trees. If there is a heavy migration of aphids from elm to apple, nursery stock may be sprayed with a nicotine solution, such as is recommended for the black peach aphis. This should be applied in late May and again in June. The migrants and their colonies are thus destroyed before individuals have a chance to infest the roots.

4. If the roots of a tree have become infested there is probably no better remedy than keeping the tree in good condition by proper cultivation and fertilization.

An infestation on the tops of apple may be destroyed by spraying with a nicotine solution as before described. This spray may be applied at any time but the greatest numbers of aphids are usually present during the autumn months. If the trees are young it is practicable to carry a pail of nicotine solution from tree to tree and apply it to the colonies with an ordinary paint brush.

The white aster root louse.—No one thing should be relied upon to control this aphis. The following recommendations should be combined against it:

1. Keep the plants in good condition by cultivation, fertilization, and watering.

2. Avoid planting asters on ground that has recently grown such plants as wild asters, golden-rod, or any general mixture of weeds. Such plants are frequently infested and the ants simply transfer the aphids to the aster roots.

3. If a large planting of asters is to be made, plow the ground and cultivate it frequently for some time before planting.

4. If plants become infested, pull away a small amount of earth from the roots and pour about them from a pint to a quart of nicotine sulphate solution, made according to the formula on page 223.

BIBLIOGRAPHY

Not otherwise listed

Baker, A. C., 1920, Generic classification of the Hemipterious Family Aphididae. U. S. D. A. Bul. No. 826.

Courchet, L., 1878, Etude sur le Groupe des Aphides et en particulier sur les Pucherous du Terebinths et du Lentisque.

Courchet, L., 1879, Etude sur les Galles produietes par les Aphidiens.

Derbes M., 1869, Observations sur les Aphidiens qui font les Galles des Pistachiers. Ann. Der. Soc. Nat. Zool. XI.

Forbes, S. A., 1893, Eighteenth report of the State Entomologist on the noxious and beneficial insects of the State of Ill., pp. 48-94.

Forbes, S. A., 1915, Twenty-eighth report of the State Entomologist on the noxious and beneficial insects of the State of Ill., pp. 1-60.

Hartzell, F. Z., 1919, Comparison of methods for computing daily mean temperatures: Effect of discrepancies upon investigations of Climatologists and Biologists. N. Y. Agr. Exp. Station, Technical Bul. No. 68.

Mordvilko, A. K., 1922, The woolly apple aphis *(Eriosoma lanigerum* Hausmann) and other Eriosomea. Comptes Rendus de Academie des Sciences de Russie, 3 M. 1, XII.

Mordvilko, A. K., 1923, On the Distribution of some groups of aphids in connection with their past. Comptes Rendus de Academie des Sciences de Russie, 3 M. 13, III.

Patch, E. M., 1916, Concerning problems in aphid ecology. Jr. Econ. Entomology, vol. 9, pp. 44-51.

Tan, Jose P., 1924, The rice Root Aphis *(Dryopeia hirsuta* Baker). The Philippine Agriculturist, vol. XIII, No. 7, pp. 277-286.

Thomas, Cyrus, 1879, Eighth report of the State Entomologist on the noxious and beneficial insects of the State of Ill.

PLATE I.

A. *Anoecia querci,* wings.
B. *Anoecia corni,* wings.
C. *Anoecia querci,* antenna of alate form.
D. *Anoecia querci,* antenna of apterous form.
E. *Anoecia querci,* antenna of alate form.
F. *Anoecia corni,* antenna of alate form.
G. *Anoecia corni,* antenna of apterous form.
H. *Anoecia corni,* cornicle of alate form.
I. *Anoecia* sp., apterous form.
J. *Anuraphis viburnicola,* antenna of apterous form.
K. *Anuraphis crataegifoliae,* antenna of apterous form.
L. *Anuraphis crataegifoliae,* antenna of alate form.
M. *Anuraphis viburnicola,* antenna of alate form.
N. *Anuraphis bakeri,* antenna of alate form
O. *Anuraphis bakeri,* antenna of apterous form.
P. *Anoecia corni,* cauda of alate form.

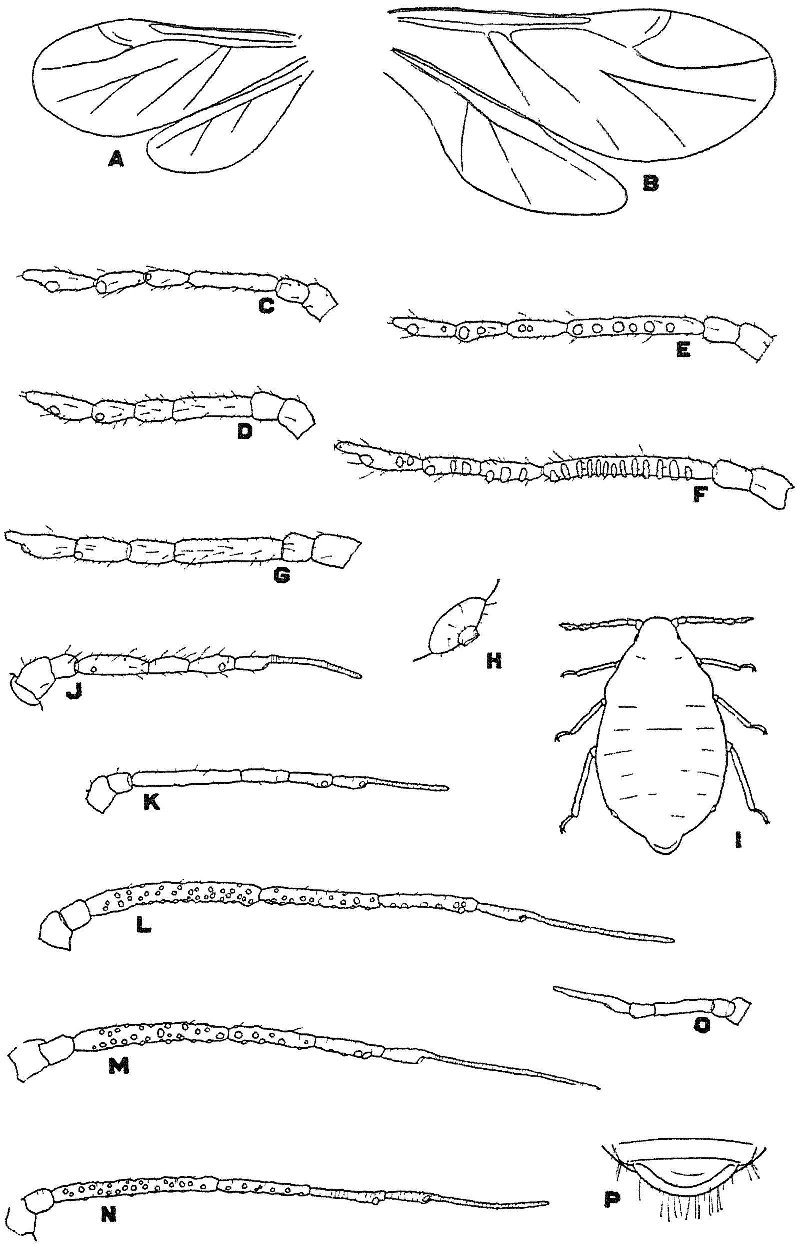

PLATE 1 C R Cutright, Del

PLATE II.

A. *Anuraphis maidi-radicis*, antenna of alate form.
B. *Anuraphis maidi-radicis*, antenna of apterous form.
C. *Anuraphis persicae-niger*, antenna of apterous form.
D. *Anuraphis persicae-niger*, apterous form.
E. *Anuraphis maidi-radicis*, antenna of apterous form.
F. *Anuraphis persicae-niger*, cauda of apterous form.
G. *Anuraphis persicae-niger*, cornicle of apterous form.
H. *Anuraphis persicae-niger*, cauda of alate form.
I. *Anuraphis persicae-niger*, cornicle of alate form.
J. *Anuraphis persicae-niger*, antenna of alate form.
K. *Anuraphis persicae-niger*, alate form.

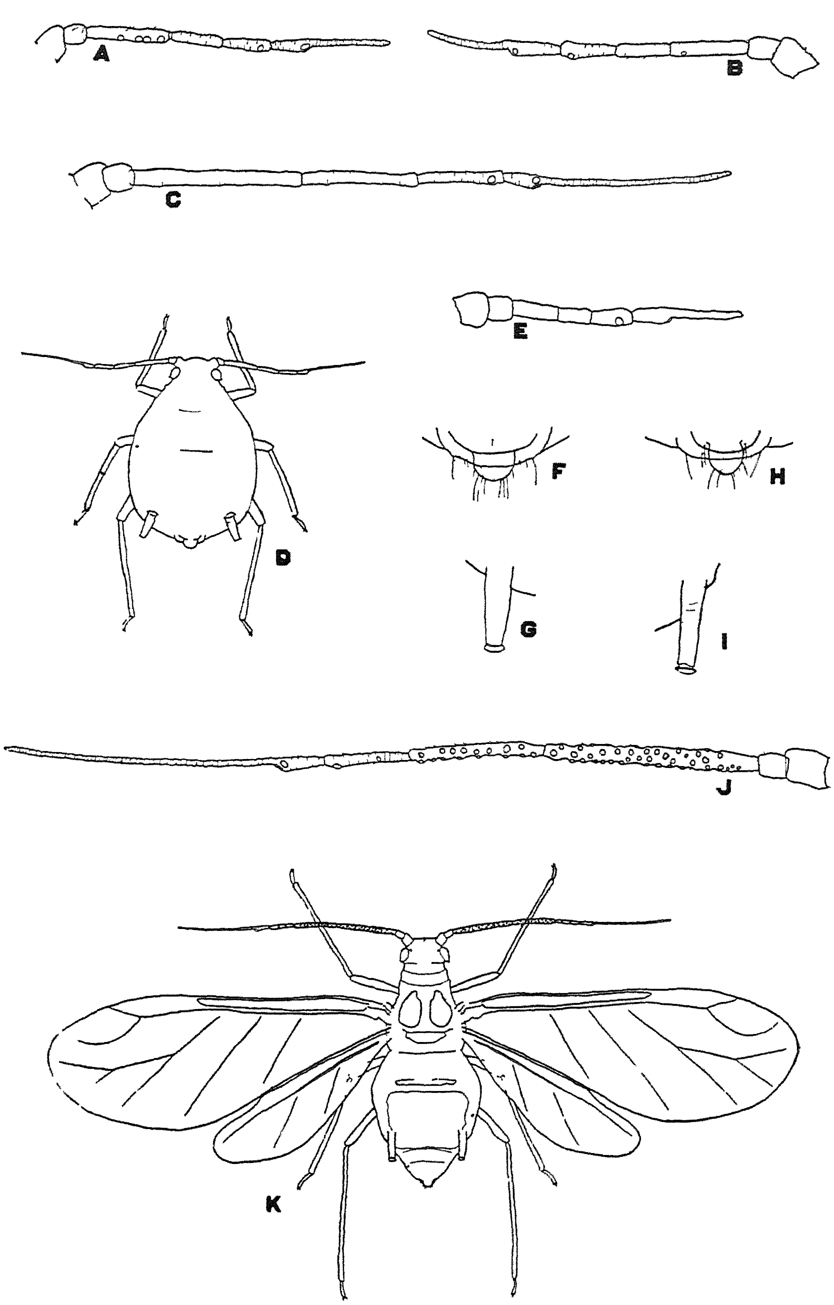

PLATE II

C R Cutright Del.

PLATE III.

A. *Forda olivaceae*, alate form.
B. *Forda olivaceae*, antenna of alate form.
C. *Forda olivaceae*, antenna of apterous form.
D. *Prociphilus erigeronensis*, apterous form.
E. *Prociphilus erigeronensis*, cauda of alate form.
F. *Prociphilus erigeronensis*, antenna of apterous form.
G. *Prociphilus erigcronensis*, antenna of alate form.
H. *Prociphilus erigeronensis*, alate form.

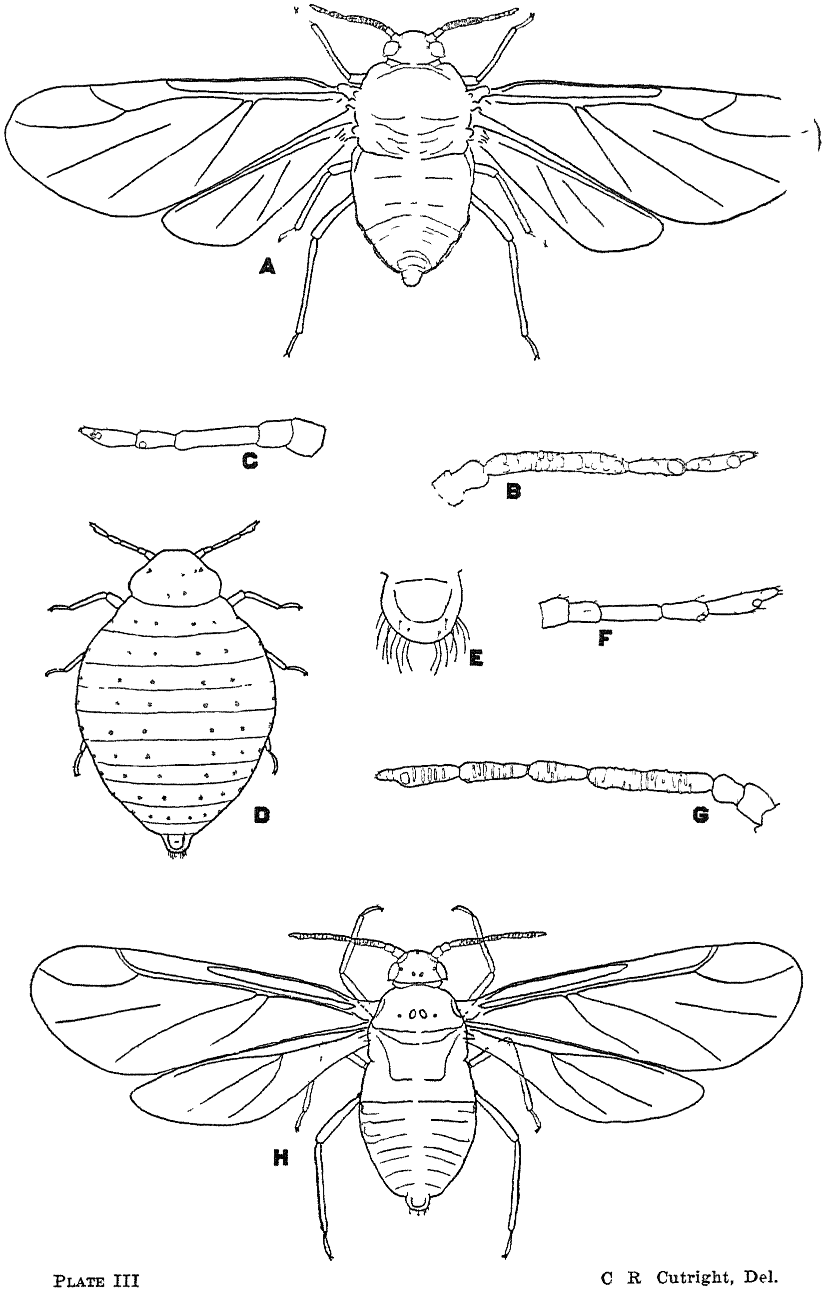

PLATE III

C R Cutright, Del.

PLATE IV.

A. *Pemphigus lactucae*, antenna of apterous form.
B. *Pemphigus lactucae*, antenna of apterous form.
C. *Pemphigus lactucae*, alate form.
D. *Pemphigus lactucae*, antenna of alate form.
E. *Pemphigus lactucae*, apterous form.
F. *Geoica radicola*, antenna of apterous form.
G. *Geoica radicola*, antenna of alate form.
H. *Geoica radicola*, alate form.
I. *Geoica radicola*, apterous form.
J. *Geoica radicola*, first instar nymph.
K. *Geoica squamosa*, antenna of alate form.
L. *Geoica squamosa*, antenna of apterous form.
M. *Geoica squamosa*, alate form.

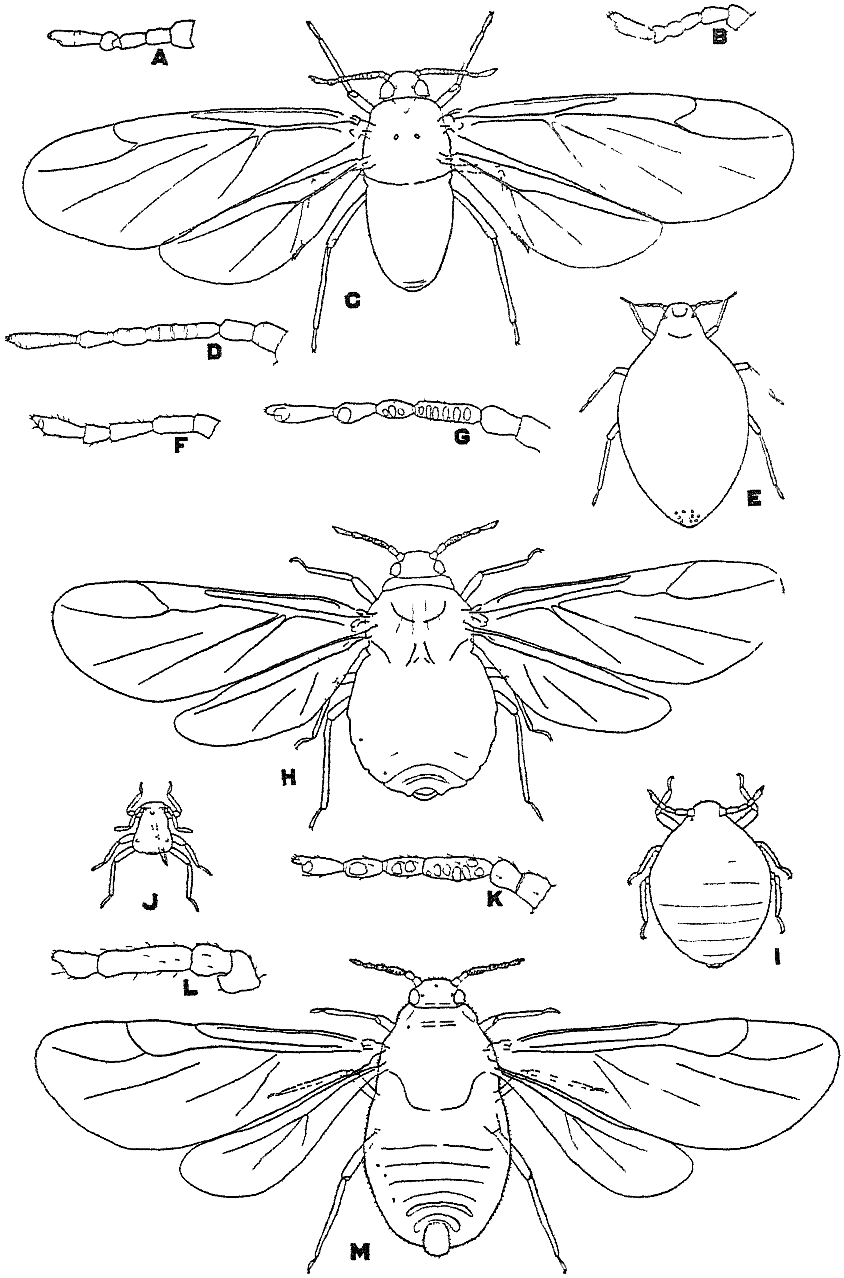

PLATE IV

C R Cutright, Del

PLATE V.

A. *Anoecia corni*, fall migrants and sexual forms on *Cornus* (dogwood) foliage.

B & C. *Anoecia corni*, spring migrants on *Cornus* flower buds.

D. *Anuraphis persicae-niger*, (black peach aphis) "cow shed" built by ants over a colony at the base of a young peach tree.

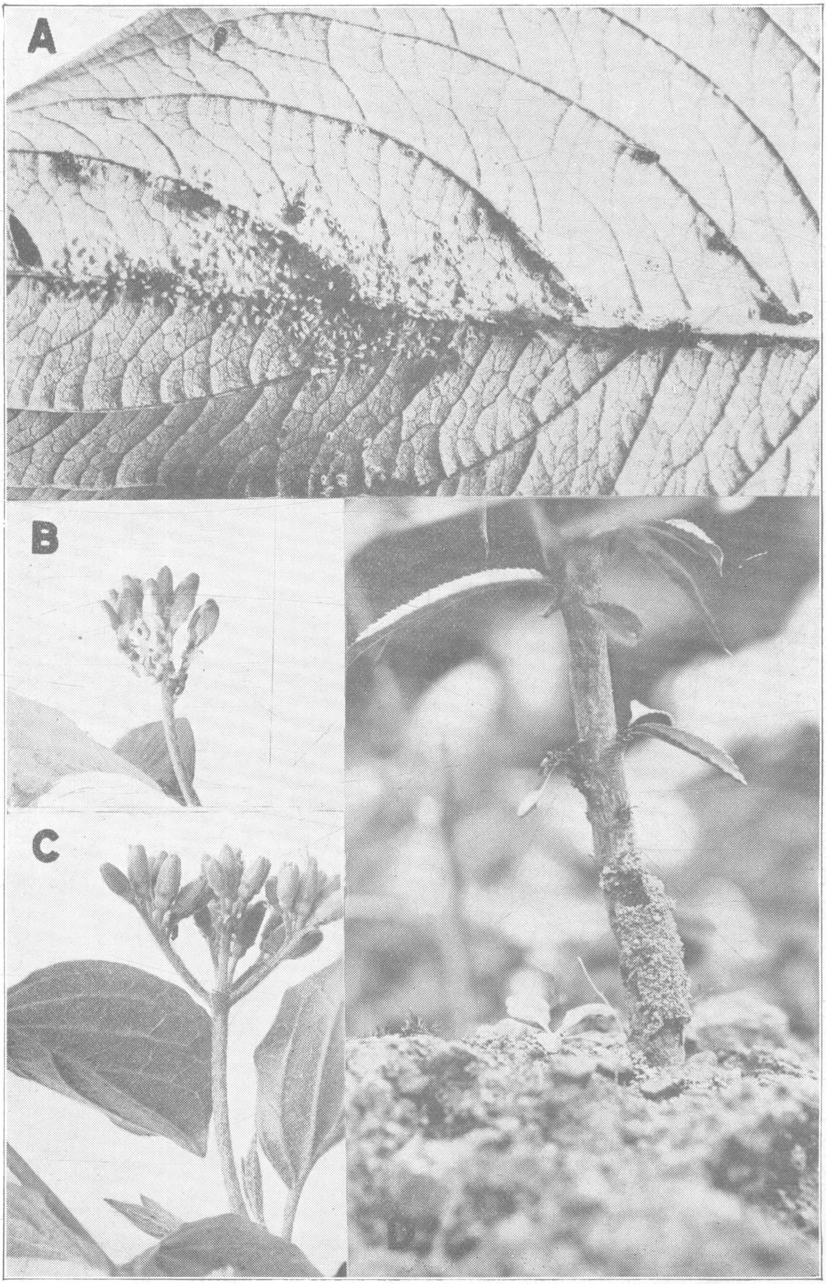

PLATE V

PLATE VI.

A. *Anuraphis persicae-niger*, (black peach aphis), colony on the terminal of a young seedling tree.

B. *Anuraphis persicae-niger*, colony on stem of young tree (slightly enlarged).

C. *Pemphigus lactucae*, colony on roots of *Solidago graminifoliae* (goldenrod). The insects used to start this colony had been kept over winter in the soil without food.

D. *Prociphilus erigeronensis*, (white aster root louse), overwintering colony in ants' nest.

PLATE VI

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